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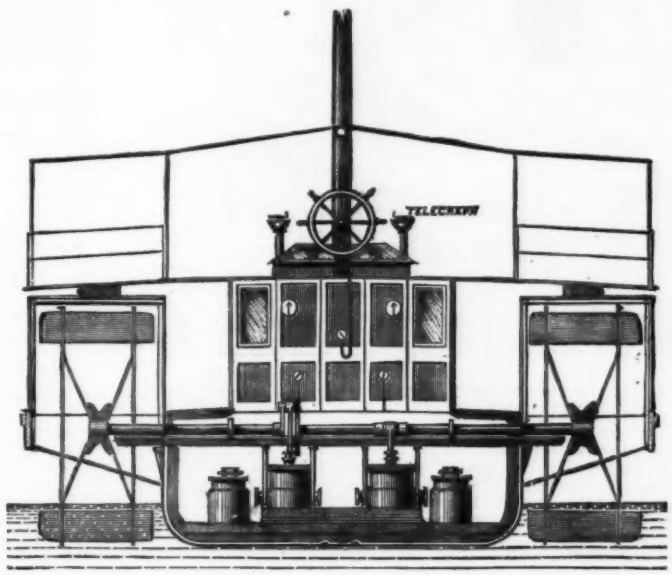
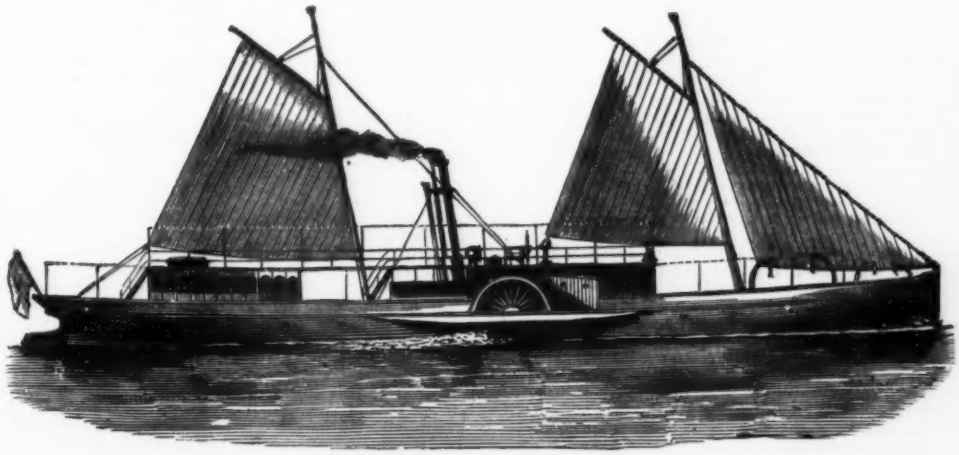
THE S.S. SILVA AMERICANO.

THE paddle steamer which we illustrate herewith has been designed and constructed by Edwards and Symes, of Cubitt Town, London, for the Portuguese Government, for navigating the upper waters of the river Quanza, which flows through their settlement on the west coast of Africa. The construction of the boat, which was lately tried, was under the superintendence of Captain C. Alexander, F.R.G.S., who was specially commissioned for this purpose on account of his experience in the navigation of the Quanza, and his having made a complete survey and map of its course, by which he has become thoroughly acquainted with the requirements of the river and its traffic.

For several years past much interest has been displayed in the possible trade with Central Africa, and with the idea of extending the commerce in these great virgin districts, companies have been formed who have taken advantage of the assistance afforded by the rivers where navigable. The settlement in Angola above referred to is one of the oldest in Africa. It has a capital, Loando, commanding a good harbor formed by the island of the same name as the capital, and which lies at such a distance from the coast as to make the waters between it and the land into a comparatively smooth shelter. Many steamers have for a long time been engaged in the carrying trade on the Quanza from this port, but hitherto those of sufficient size have drawn too much water to enable them to pass high enough up the river in the drier seasons, although several have been made in this country professing to draw but 24 in.

The Silva Americano is 140 ft. long by 18 ft. beam, constructed of iron and steel; the terms of contract being that she should carry 20 tons of cargo on 24 in. of water at 10·4 knots per hour. All the parts which are likely to be exposed to extra strain or wear, either on the voyage out or on service, are of Siemens' steel from the Landore Works. There is no outside keel, but she has an inside steel keel plate, extending from stem to stern, with strong engine bearers and boiler keelsons. The whole of the central compartment, containing the machinery, having extra floors and deck ties, which proved so efficient that, when in dry dock on bilge blocks, to put on the false keel hereafter referred to, no deflection was perceptible with water in the boiler, though this is frequently the case with light draught steamers. She is fitted, for the voyage out, with a wood false keel 105 ft. long, 2 ft. deep, secured to the bottom by strong angle irons, which add both to the strength of the hull and the stability of the vessel. The space below deck fore and aft the engine-room is intended exclusively for cargo, there being side lights and one large hatch to each, commanded by derrick and winch, attached to each mast. She is fore and aft schooner rigged, and on the main deck is fitted a nice light saloon and cabin for passengers and crew, with a light bridge or awning deck above, carrying airing for the climate. All the skylights and sashes are fitted with copper mosquito netting of twenty-four meshes to the inch. On the sponsons are fitted the baths and other accessories. The vessel is steered by a wheel on the bridge deck, as shown, with telegraph to engine-room on either side. The head and stern carvings, which are of unusual character, represent African scenery. A patent zinc lifeboat is carried by davits in the usual manner. The engines are of the injection condensing, oscillating type, with disconnecting gear, so that either engine may be worked separately if required, at varying speeds, or in opposite directions, with separate telegraph to each engine. They have been constructed by Messrs. J. Penn & Sons for the contractors, and are of the type usual on the London river steamboats, lightness being necessary to meet the conditions of contract. The cylinders are 24 in. diameter by 2 ft. 4 in. stroke, with steel piston and valve rods, cast iron top and bottom framing of their usual type, and fitted with hand gear, which is worked from the main deck. The crank shafts are of wrought iron, with eccentrics for working the air-pumps, so as to avoid the cranked shaft, which is occasionally the cause of accident by fracture, a matter of considerable importance in an uncivilized country. The paddle-wheels are 11 ft. 6 in. diameter, with common radial boards—with provision for reefing up for the voyage out—the dip in the water being only about 18 in. The boiler is of the square tubular type, with brass tubes. 154 in number, 2¼ in. diameter, with extra large furnaces and grate, adapted for burning wood. The furnaces and tube plates are of Lowmoor iron, the remainder BB Staffordshire iron, and the working pressure 30 lb. per square inch. On the trial which took place on the 31st ult. this boat more than fulfilled the conditions of the contract already referred to, and reflects great credit upon the designers and builders; the draught of water with 27 tons of cargo on board being only 22¼ in., and the speed 10·39 knots per hour, being the mean of six runs on the measured mile, with a strong side wind, which considerably affects boats with less than 2 ft. in water and 12 ft. out. The boat is, of course, intended to carry very much more than 27 tons, but 20 tons was the stipulated weight for a draught of 2 ft. The trial which we witnessed showed that the boat is admirably adapted to the work she is intended to perform, and a second run has proved that the engines may be made to run in contrary directions, even with the deep keel affixed.—*Engineer.*





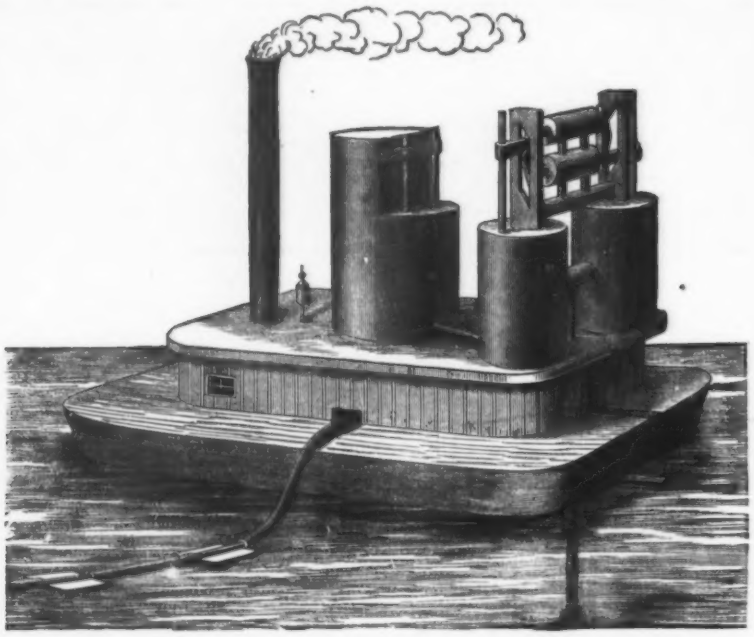
NEW STEAMBOAT FOR SHALLOW WATER.

THE RUSSIAN CIRCULAR IRONCLADS.

THERE are in the Black Sea at present the two circular ironclads which Mr. E. J. Reed at one time lauded in no measured terms as the typical war ships of the future. It will be remembered that we have from time to time taken strong exception to the soundness of his opinions in this respect. The cyclads, which were to do so much, have done absolutely nothing during the present war—the reason why being very fully set forth in the *Moscow Gazette*, which may be regarded as a leading Russian journal. It appears that, to say nothing of their other imperfections, they are so badly ventilated that it is impossible to fire their boilers properly. Just now Admiral Popoff is the best abused official in Russia. The comic papers speak of his circular ironclads as "Popoff's stewpans." There is in existence another Russian ironclad which Mr. Reed once described as probably the most powerful ironclad in the world. This has been so badly put together that she leaks at every seam, and is known in Russian naval circles as the "Colander." A Russian officer, writing to the *Moscow Gazette*, sums up the present position of the navy in the follow words:—"For seven years we have been spending time and money on the Peter the Great and the two Popoffkas, with the result that when wanted they are not of the slightest use."—*Engineer.*

DENNISON'S "INGURGITATOR" DREDGE.

THIS dredging machine, as its name indicates, is constructed on the suction principle. It raises the material from the bottom of a river, lake or bay, and conveys it to any distant point either over land or water. As a levee builder it is unexcelled. It has long been known that mud taken from the bottom of a river will make an embankment of peculiar strength when once it has settled and dried, and not easily destroyed by overflow of water. This machine takes advantage of this fact and works to double purpose, by deepening the channel and procuring the best material for a levee at the same time operation. It mainly consists of two steam vacuum pumps provided with suitable telescope suction pipes, extending to the bottom of the water, through which the mud is raised by a vacuum produced by filling the cylinders with steam and then condensing it. The mud is forced from the cylinders into a pressure tank, and from there forced through pipes to the discharging point.



DENNISON'S "INGURGITATOR" DREDGE.

This machine has been in operation at Union Island, San Joaquin river, for nearly six months, raising a thousand cubic yards per day with a three foot cylinder. It is to be put to mining in some of our river beds also, as this new system of mining is becoming quite popular in the upper rivers. We may soon expect to see the suction tubes feeling their way over the beds of our gold-bearing rivers, searching for the precious metals like an elephant's trunk hunting for a pin in a bucket of water, and on the same principle.—*Min. and Sci. Press.*

SOFT STEEL AND INGOT IRON.

A PROCESS for the manufacture of so-called soft steel or ingot iron, containing as low a percentage of carbon as ·10, or possibly lower, or (say) containing an amount of carbon ranging from ·18 to ·10—that is to say, a soft steel can be made at any notice containing any desired amount of carbon within the range mentioned—has been patented by Messrs. Harvey, of North Woolwich, Eng., who propose to produce a soft steel especially suitable for wire ropes, telegraph wires (where very low electrical resistance is required), cable wire, and wire of various kinds which have to stand great elongation, twist, breaking strains, or other tests. Also for engines and other forgings, nail-making, plates, sheets, hoops, and every purpose where metal is required superior to charcoal iron, and where greater tensile strength, ductility, and toughness are required than can be obtained from the best wrought iron worked in the ordinary way. The furnace preferred for this manufacture is the well-known so-called "Siemens' regenerative" open hearth steel melting furnace, which is heated by coal gas and atmospheric air; or other regenerative gas or reverbatory flat-bottomed furnace may be substituted, capable of supplying a heat sufficient to melt wrought-iron, and keep the said wrought-iron in a fluid or a molten state for some time. A tap-hole is provided at the back of the furnace through which the finished metal is run out. The said metal may first be run into a ladle of requisite capacity as is usual, and from thence it is tapped into round, square, or other shaped moulds, as may be required to suit the purposes for which it is intended.

The improved process consists in charging on the bottom of the furnace (such furnace to have attained previously the highest temperature, or nearly so, which it can command) from 40 to 50, or (say) 45 per cent. (of total charge exclusive of ore) of pig iron, the quality of which pig iron shall be hereinafter specified, to which is added on charging 10 per cent. of ore, which ore will begin to oxidise the carbon contained in the pig iron as soon as the latter melts, and if the pig iron contains less manganese than 1·5 per cent., the manganese in the pig iron must be made up by charging with the pig iron from 1 to 4 per cent. of spiegeleisen containing 20 per cent of manganese; thus, if the pig iron contain about 1·5 per cent. of manganese no spiegeleisen is charged, but if it contain (say) only ·5 per cent. of manganese then about 2 per cent. (of total charge exclusive of ore) of the said spiegeleisen should be charged. Different raw material is used according to the tests which it is intended that the finished metal should be best able to bear.

When the whole is melted a little more air is put on in order to assist in decarburizing the metal, and the full heat is kept up until the ore has all worked off the surface of the metal or until the ore has become reduced by the action of the carbon contained in the pig iron. At this time the metal will be seen to sink below the entire surface. A sample of the boiling metal should now be taken out, cooled in water, dried, and hammered on a smith's anvil; if on the first blow it breaks and flies 1 cwt. (about) of ore should be thrown in, which operation is repeated until the sample stands a blow on the anvil without fracture, thereby indicating that the metal contains from ·60 to ·75 per cent. of carbon. When this point is reached, from 30 to 40 per cent. (of total charge, exclusive of ore) or (say) 35 per cent. of wrought iron or soft steel scrap is charged on the banks of the furnace, in small quantities at a time, say 5 to 10 cwts at either end, which wrought iron, in whatever shape, is allowed to melt almost entirely by heat while still on the banks, without being pushed into the bath of metal. That portion, however, of the wrought iron or soft steel scrap which is charged much above the level of the metal may with advantage be turned in when at a good white heat, in order to save waste by oxidation. The object of this mode of charging the wrought iron or soft steel scrap is to prevent the cooling of the molten metal, which would probably result if the charges were introduced without previous heating, thereby incurring the risk of portions assuming a pasty condition, instead of being uniformly thin and well melted. Should the furnace, however, be working very hot, some of the wrought iron or steel scrap may be turned in with advantage when at a good heat. During this melting in of the wrought iron or steel scrap, the flame should be kept bordering on a non-oxidizing quality.

By running in the wrought iron or soft steel scrap as described, and at this period it liquifies and renders very thin the thick scum or too silicious slag which accumulates on the surface of the molten pig iron after being nearly decarburized by the ore, as is the case in working the so-called "pig and ore" process, thereby preventing the heat (gas and air) from penetrating through the metal, and so retarding the decarburizing effect of the oxygen contained in the flame, and increasing the liability of the metal to assume a pasty condition and sink to the bottom by reason of the deficiency of heat; but after the wrought iron or soft steel scrap is run in, the slag being in a very liquid state allows the heat and flame to penetrate perfectly, thereby preventing the metal from sinking to the bottom. Owing to the wrought iron containing but little carbon it is found that when the whole of it is run in the manner described the said wrought iron by its diluting action and the oxygen in the flame by its decarburizing action (during the time the wrought iron was melting) will have reduced the carbon contained in the metal to not more than ·14 or ·15, and sometimes even lower, thus reducing the carbon much quicker than by working with ore for the same object, as the time required for the melting in of the wrought iron does not exceed 1½ hours, though it is possible to work it in less time than this.

When the whole of this wrought iron or soft steel scrap has been melted and turned well in the bath of metal, a rabble is inserted to ensure a thorough admixture of the wrought iron or steel scrap with the other metal. A piece of ore should now be thrown into the bath; and if after a minute or two the ore floats on the surface, and there appears to be no action between the metal and the ore, or the ore is only reduced with difficulty, this is an indication that nearly the whole of the carbon has been practically eliminated—that is to say, that the carbon contained in the metal has become so low that neither the ore nor the oxygen of the flame has any perceptible burning or taking out action on the carbon that remains; but if the ore disappears after two or three minutes this is an indication that a little more ore is required, which is accordingly thrown in at intervals till there is no action, as above explained. When this is the case no more ore is required, but a full heat is kept up for 15 or 20 minutes, so that the oxygen in the flame may possibly burn out a little more of the carbon, and the metal will thereby be considerably heated.

When nearly the whole of the carbon has been eliminated the surface of the bath of metal will show numerous thin and very liquid pools, like water, and on which the heat seems to have greater effect than on the remaining surface. A sample now taken out will be found to contain about ·12 per cent. of carbon. When this point is reached wrought iron ranging from 10 to 30 per cent. or higher (of the total charge exclusive of ore) is introduced, according to the carbon required in the finished metal—that is to say, if soft steel containing ·10 per cent. of carbon is required, then from 23 to 30 per cent. of wrought iron must be added. If ·15 per cent. of carbon is required, 17 per cent of wrought iron must be added, and so on, the quantity charged being in proportion to the carbon required. Such wrought iron should be put in in quantities of 5 or 6 cwts. or more at a time on each bank, and allowed to melt in entirely by the heat of the furnace without pushing in any part thereof, except that which is the furthest away from the metal, which should be turned into the bath at a white heat. In this way the metal will maintain its full liquidity and heat, and consequently it will not readily solidify when in the ladle or elsewhere after being tapped from the furnace.

In order to dilute or reduce the amount of the carbon contained in the metal, soft wrought iron must only be here used—that is to say, iron containing less than ·1 per cent. of carbon, this latter being about the amount already in the metal; therefore, iron containing ·11 or ·10 per cent. of carbon or lower is used with advantage for this object. and if a soft steel be required with carbon as low as ·10 per cent. it is found best to use iron with nearly all the carbon worked out, or containing (say) ·05 per cent., or lower, as then a less quantity can be charged than if the iron contained more carbon. The carbon contained in the whole may thus be reduced to ·06 or ·07 before charging the ferro-manganese, which added to the small amount of carbon put in by the ferro-manganese will bring it to .10 per cent in the finished metal. If the carbon contained in the metal before charging in the ferro-manganese should have been reduced to ·12 or ·15 per cent by the first addition of wrought iron, and the amount of carbon in the finished material be required to be not less than ·17 or ·18 per cent., then the amount or a little more of the ferro-manganese can be charged without putting in the second lot of wrought iron. The quantity of ferro-manganese (say, ·7 per cent.) as stated below, will be found amply sufficient, provided the quantity of manganese in the pig iron charged at first be made up.

When the wrought iron in this last operation has disappeared from the banks, or has become dissolved by the molten metal, a rabble or bar should be frequently inserted and stirred about in order to assist in bringing the same into close contact with the other metal, thereby rendering it perfectly liquid and uniform with the other metal, thereby rendering it perfectly liquid and uniform with the other existing metal. This rabbling should be renewed at intervals during half an hour after the wrought iron has disappeared from the banks, in order to bring the metal into contact with the full heat of the furnace before tapping it into the ladle A sample will now be found to contain from 6 or 7 to 11 per cent. of carbon, according to the quantity of wrought iron charged at the last operation, and according to the proportion of carbon contained in such wrought iron. A little burnt lime (say 15 or 20 lbs.) is now thrown in to assist in keeping a fluid slag, and after 10 minutes 7 per cent. (of the total amount charged, exclusive of ore) of powdered ferro-manganese containing not less than 50 per cent. of manganese is now charged into the centre of the molten bath, which ferro-manganese will melt in about two or three minutes, but in order to secure a perfect melting and union, from five to ten minutes should be allowed previous to tapping, and the metal should also be well rabbled before running out.

ROYAL CORNWALL POLYTECHNIC SOCIETY.

THE forty-fourth annual exhibition of the Royal Cornwall Polytechnic Society was held lately at Falmouth, Eng. The weather was not in all respects so satisfactory as was to be desired, but the exhibition itself was a very good one, and showed plainly enough that as this useful institution approaches its jubilee it suffers no falling off in the extent and character of its operations. Among the general departments, the fine arts may be mentioned as thoroughly up to the mark, including many loans of considerable excellence. The photographs were fewer in number than last year, but were very good. Naval architecture was a fair average and lace and art needlework in some respects of unusual merit. The chief features in ornamental art were the magnificent displays of terra cotta, from the works of the Watcombe and Torquay Companies. Natural history was meagre. However, we have not to do with these sections, but with that devoted to mechanics. This was of very high merit indeed, not merely as regarded the number but the character of the exhibits. There never was a year, too, in which so many machines had to be put to the test of actual operation. In this the Falmouth Dock premises afford facilities which could be obtained in no other town in Cornwall

Two or three personal remarks demand attention before we proceed to describe the most salient features of the mechanics of the exhibition in detail. Since the last exhibition one of the oldest friends of the society, Mr. R. W. Fox, has passed away from an honored and happy old age; but his daughter, Miss Fox, to whom the first suggestion of the society was due, evinces as much interest in its proceedings as ever, and has been actively occupied in some of the departments this week. Mr. Richard Taylor, F. G. S., the President of the year, was, when the society started, its first honorary secretary; and it singularly happens, too, that Mr Jordan, who 40 years ago was its first paid secretary, has this year visited Falmouth for the first time for twoscore years with a hand borer of his invention.

The Rider compression engine (American) was shown by Messrs. Hayward Tyler & Co., both in the hall and at the docks, where a half-horse engine worked admirably. This is the first time that a caloric engine has been shown at the Polytechnic, and the Rider is beautifully simple. The leading features are the use of highly compressed cold air, its thorough heating without change of volume, and its efficient expansion to a point to or below the pressure of the atmosphere, and this is accomplished without the use of valves, springs, levers, or any delicate work whatever, the only moving parts being the plunger shafts and connections. One of the great advantages of the engine is its small compass, as it requires no boiler; others are its freedom from all possibility of explosion, and its handiness of management, as it can be run by anybody. The firing up does not need to be done oftener than once in three-quarters of an hour, and the consumption of coke is only 6 lbs. per horse-power per hour. It received a first silver medal.

Messrs. Hayward Tyler, in addition to their Rider engine, exhibited a model of one of Cope & Maxwell's patent self-governing steam pump engines, with an additional wooden model effectively indicating in section its peculiar valve motion. The result is effected by a combined movement given by an auxiliary cylinder and cataract which moves with the main piston. If the engine runs away it overruns the action of the auxiliary cylinder, and instantly cuts off the steam. If extra work is thrown on the engine, the auxiliary cylinder, on the other hand, overruns the cataract, and more steam is admitted. To this a second silver medal was awarded.

The Phosphor Bronze Company obtained a first silver medal for a large collection of exhibits illustrating the various uses to which this invaluable alloy can be and is put. Our readers are aware that phosphor bronze is a com-

pound of tin, copper, and phosphorus in certain proportions, according to the special work required. Among the exhibits were several bearings that had been in constant use for long periods without appreciable injury, and a plunger that had been in operation 572 days without giving any evidence that it had been at work at all. Few bett_r illustrations of the wear-resisting properties of phosphor bronze could have been afforded.

The Pulsometer (American) shown by Mr. Warrington is one of the quaintest and most peculiar little machines that has been seen for a long while. In principle its inventors, Messrs. Hodgkin, Neuhas & Co., have really fallen back on the old fire or steam-engine of Savary, itself an improvement on the famous suggestion of the Marquis of Worcester. But the details are new, and the result is that we have here a pumping apparatus calculated to be of special utility under many conditions. It will raise water and other liquids 50 to 80 ft. without the intervention of any of the usual compo nent parts of a pumping-engine. There are no cylinders, piston-glands, stuffing-boxes, or rods. It consists simply of a couple of steam-chambers, containing alternately the liquid pumped and the pumping steam. The valves are simple balls. The action depends entirely upon the condensation of the steam and the formation of a vacuum. This admits the water, which is again driven out by the steam, and the alternate repetition of the process in each chamber keeps up a continuous stream. The pulsometer was fixed in the graving dock at Falmouth, and worked admirably. The origin of the name will be readily seen in the alternate pulsation of the liquid in the chambers, which may be compared, in short, to the ventricles of the heart. The same principle has been utilized with the utmost success on a machine for feeding boilers, under the name of the "hydrotrophe." The details, however, differ widely from those of the pulsometer, to suit the altered character of t_e work required. A second silver medal was awarded for both.

Mr. Jordan, in his patent pneumatic rock-drill, has elaborated a novel mode of using the elastic force of compressed air, which is likely to be found useful for many purposes and in many situations where the employment of power drills is impossible. The working parts of the machine consist of close cylinders fitted with a piston so arranged as to be perfectly air-tight during its up stroke. The piston is drawn up through its stroke by a cam on a revolving shaft at the rate of about 200 strokes a minute, and the revolving and forward feeding motions of the drills are at the same time secured by the percussion and friction of the cam on the face of the lifting-block, so that all the requisite movements of the block are automatic. The machine exhibited was driven by two men at winch handles, but power could easily be applied. A blow of any required force within the limits of the power can readily be obtained, because it depends on the relative length of stroke and the space above the piston at its termination. Up to four atmospheres on the surface of the piston may readily be utilized in this way. No inconvenience arises from heat generated by compression, because it is instantly taken up by the expansion of the same quantity in hastening the down stroke. Thus drills may be fixed in any situation, and worked by any men capable of turning a grindstone. It is thoroughly independent of all connection, is very portable, and is likely from the cheapness of the outlay required to come into very general use. It obtained a second silver medal.

Messrs. Le Gross, Mayne, Lever & Co. exhibit the "Ingersoll" (American) drill, with improvements. It was worked at the docks with the greatest success, driving a hole of 2 ft. deep into the hardest granite at the speed of 4 in. a minute, the number of blows per minute averaging 700. The Ingersoll has been exhibited at Falmouth before, but it did not work then with the same thorough success as yesterday. The chief improvements consist in the shortening of the cylinder by 1½ in., and the bringing of the valves close together, which results in considerable economy of power. A first silver medal was awarded, the judges remarking that no drill shown at Falmouth had ever worked better.

The "desideratum" rock borer, exhibited by Messrs. Le Gros, Shaw, Clark & Co., unfortunately could not be worked before the judges in consequence of an accident to the piston. The mechanism is very simple; there is only one tappet-valve, and this working is perfectly automatic. By the arrangement of a patent ride suit the piston has the whole of its top area exposed to the steam or compressed air when giving the blow, and is propelled with full power until the bit strikes the rock, when by the valve arrangement a cushion is formed at the end of the cylinder to protect it from injury. A cushion is also formed in the top end of the cylinder on the return stroke. The machine but for the unfortunate casualty —slight in itself, but not admitting of immediate reparation at Falmouth—would, undoubtedly, have done well.

Messrs. Hathorn & Co. made a very successful trial of their air-compressor, calculated to work four drills. It is a very convenient form, is moderate in price, and does not require any masonry foundations. The air is delivered at any speed or pressure. The valves and valve-seats can be seen without breaking a joint, which is, of course, a very great advantage, and the other special recommendations claimed are that the heat by compression is reduced to a minimum, absolute economy in first cost and after working. The compressor was highly commended. A model was also shown in the Polytechnic Hall.

A novel form of arrangement is that of the dual engine of Mr. Somerset Mackenzie. Great increase of power is obtained in screw propellers by using two screws rotating in opposite directions, one taking the water of the other. By the use of a hollow shaft and double engines this can very easily be accomplished, but Mr. Mackenzie has discovered how to do it with one cylinder—that is, he has two reverse rotating motions from the action of one cylinder and piston. How this is managed is not very easy to explain without the aid of diagrams, but we may state that while one shaft is driven by an ordinary crank the other is driven by a kind of slotted crank, with its head passing round the other shaft as it rotates. This is the arrangement in the vertical engine—that of the horizontal, which is about to be put in a boat recently constructed, is somewhat modified, but the same in principle. Award deferred for trial at sea.

Mr. Vosper (Plymouth) had the merit of contributing one of the chief novelties of the exhibition, which was highly admired by the judges, and which appears likely to be adaptable to a great variety of uses. It is a radial drill for boring three parallel holes at once, and the beauty of the arrangement is at once manifest. A ball crank from the main axle terminates in a disk. In this are inserted other three ball cranks, smaller, and beveled so as to pass each other. Each of these drives its own drill, and thus the simple rotation of the axle is converted into the triple rotation of the drills. It is marvellously simple and effective. Another drill shown by Mr. Vosper was a convenient form of combined drill and ratchet brace for use attached to a bench. The first bronze medal was awarded to the radial.

Messrs. Le Gross, Shaw, Clarke & Co. also exhibited a very useful little instrument—Royle's patent self-cleansing steam trap, which permits air and water of condensation to escape from steam pipes without loss of steam. This was shown in action at the docks. Nothing could be more effective, and it received a first bronze medal.

Mr. Olcott (Manchester) showed a new form of press, which is capable of exercising enormous power, and which operates by a quick motion from above, the action of which is taken from the idea of the old throttle, resembling somewhat a worm and worm-wheel, and by a slower motion below, which is essentially an adaptation of the knuckle-joint levers, but worked by male and female screws from a winch, and also by a clutch lever in the center, with screws, with which alone a lad can put on a pressure of 400 tons. These presses are more rapid in their action and much cheaper on provision than the ordinary hydraulics, and at the same time are perfectly steady. It obtained a second silver medal.

Mr. Scott also exhibited his exceedingly clever dividing apparatus. This will divide at pleasure from 2 divisions up to 200,000 by a simple disk and stop, and without the use of any change wheels. The operation is, in fact, effected simply by the use of a small hinged step, carried by a movable slide placed on the edge of a plate wheel or disk. This also had a second silver medal.

Another of Mr. Scott's exhibits was a retort mouth for gasworks, which by the use of an annular steel ring and an undercut edge enables the mouth of the retort to be closed with the greatest efficiency. To this a second bronze medal was awarded.

Messrs. Howe & Co. exhibited their patent tallow cup, a very neat and capable arrangement; their low-water detector for steam boilers, which is entirely self-acting; and their patent "Monarch" stop valves, which give an unobstructed, clear, full way for air, gas, or water. They are very simple and economical, and open and shut with only a turn of the handle. The old screwed spindle is absolutely dispensed with. This was highly commended.

Mr. Holmes has invented new forms of his danger signals—one for use on land, and the other specially adapted to meet the needs of shipwreck. His signals are filled with a composition which ignites when water is admitted into the case, and which burns away brightly, and is inextinguishable. One form of signal now introduced is a shell to be fired from a mortar with life-line attached, in case of shipwreck. The other is intended to be used in case of railway accidents to illuminate the line, and act as a warning to approaching trains. In this instance the signal vessel is placed in water on a tripod stand. First bronze medal awarded.

Mr. Warrington exhibited an exceedingly clever and efficient apparatus for cutting corks. The squared pieces of cork are pressed in against a circular cutter and turned off with the greatest ease, an arrangement being made for the automatic stoppage of the feed when the supply of cork is exhausted. One of the most important features in the invention is the use of four knives in the feed groove, which slits the cork on each side as it comes to the cutter, and thus enables a circular cutter to be used. To this invention a first bronze medal was awarded. The "Warsop" light forging hammer was likewise shown by Mr. Warrington; it works with either steam or compressed air, is actuated by a treadle, and is designed to supersede the sledge hammer for ordinary heavy work. It is reported on most favorably as easy and economical, and had a first bronze medal.

Wavish's fuel economizers have been found of high value in domestic use. The inventor has now applied the principle to steam boilers, covering the bottom of the fire-box with an iron plate, and admitting the air through vertical slits in the sides of cylinders projecting upwards into the fuel. Professor Gardner, who has tested this new economizer in practice, reports a gain of 50 per cent. in economy of fuel as the result of the application of this arrangement. This economizer was tried at the docks, and appeared to do well, but the judge thought it should be further tested before its capabilities could be fully settled.

Messrs. Korting Brothers sent an elaborate working section model of their injector, which makes the nearest approach to the delivery of boiling water into the boiler, delivering it at 170°. This is an advantage which practical engineers know how to appreciate. Another advantage of the injector is that it makes the circulation more uniform. It is rather of a complicated character, and hence is not very low priced, but the advantages which it offers renders it very valuable, and high testimony is borne to its utility in action. It was highly commended.

Messrs. Whitley Partners exhibited the "Allen governor" (American), which is an exceedingly ingenious and useful arrangement. A fan works in a drum partly filled with oil, and is driven at the rate of 350 to 450 revolutions per minute. This governor has been thoroughly tested, and has been found invariably to maintain the requisite speed, whatever may be the fluctuations with regard to the machinery, as long as there is sufficient steam made in the boilers to do the work. The high rate of speed acts advantageously in making the governor very sensitive. A first bronze medal was awarded. Messrs. Whitley also showed Symons' patent "Standard" hand and steam pumps, which closely approximate to syphonic action. It is an eccentric pump—the principle of the disk engine applied to pumping—and is a combined suction and force pump. It may be driven up to 1,000 revolutions per minute.

Smith's patent "Steam Sentinel" safety-valve for preventing explosions from over pressure of steam is a decidedly clever idea. It combines a perfect safety-valve, pressure indicator, and alarm, and operates by a spring, to which, as it is provided with a double seat, the steam can have no access. These valves are regulated to any pressure, cannot be tampered with, and, therefore, sound an alarm directly the working pressure is exceeded. Such a valve, as was reported at the enquiry, would have prevented the Thunderer catastrophe. For it Mr. Warrington received a first bronze medal.

The Lavendon lamp is an exceedingly useful application of the steam jet to the combustion of hydrocarbon oils. It was much admired by the judges, and a first bronze medal was awarded.

Among the minor exhibits of merit was Loft's patent check till, which is an absolute check upon any kind of dishonesty short of carrying the till bodily away. It records whenever and how often the till has been opened, the cash taken out, how much money there ought to be in it, and many other things too numerous to mention here, each and all valuable to the employer. The testimonials in its favor are very numerous and very strong. It was highly commended.

Loft's bottle washer is also very ingenious. It was also exhibited in model, and a second bronze medal given.

As a very clever and useful device for household purposes we may commend Linder's pneumatic bell arrangement, which was shown in working order and highly commended. It is a formidable rival of the telegraph bell apparatus, which has come so largely into use.

Messrs. Wright's "Eclipse" gas-making machine—an apparatus for the production of air gas from benzoline—was shown in operation, and worked admirably. The gas produced a clear, white, steady light. It received a first bronze medal.

One of the greatest novelties exhibited—not mechanical—was the "aptus coloratus" carpet, invented by Mr. Gloyn. This is a *paper* carpet designed to imitate parquet flooring; the paper being printed in patterns to imitate different woods from photographs, so that the *vraisemblance* is absolutely perfect. The floor is prepared by being made perfectly level, and crevices filled up with plaster of Paris. Over this hessian is stretched, and on this first lining paper, and then the patterned paper is pasted, the whole being finished with a coating of a peculiar varnish, wonderfully hard and wear-resisting. This carpeting, of course, can be kept perfectly clean with the greatest ease, and though the wear of paper carpet may be thought problematical, Mr. Gloyn testifies that he has had rooms carpeted with it for 16 months without showing appreciable signs of wear. There is a wide field of utility open to the use of the photographic grained paper in many ways, for it is the most remarkable imitation of ornamental woods ever produced. It was recommended for trial.

Among other articles shown may be mentioned a cheap and handy little printing press, the Caxton, Mr. O. B. McCallum; some pulley blocks, which are not very noteworthy; a new pocket telescopic and folding stethoscope by Mr. Kempe; a working model of Davey's patent hydraulic pumping-engine, as used for draining the underlie workings in mines; an harmonograph, and various minor matters.

The Wheeler & Wilson Sewing Machine Company had a second silver medal for new arrangement; and a bronze was awarded to the "American," which can be used by the blind.

Altogether, the department of mechanics made the largest and most interesting show that had been seen at the society's exhibition for some years.

Prof. Graham Bell's marvelous instrument the telephone (American) was exhibited and illustrated in the presence of crowded audiences by Mr. R. N. Worth, F.C.S., curator of the society. It was awarded a first silver medal.

The Watcombe Terra Cotta Company were awarded a first silver medal for their beautiful exhibits.—*Mining Journal.*

POSTS AND SHORES.

POSTS.

Posts are upright supports or pillars, serving the office of columns, for sustaining the upper parts of buildings, and are themselves subject to compression. The best form is that presented by nature, in the round tree, because the substance is symmetrically arranged about the axis; but practically we have to do with material of foreign growth, squared before imported; and, partly at least from this commercial circumstance, the cylinder commonly gives place to rectangular figures. A square pillar, however, has great stability of form, and suits a vertical position.

Under a pressure of about 4,000 lb. (or less, according to Mr. Laslett) on the square inch, fir is shortened, expanded, split, and burst. It would safely bear 1,000 lb. per inch; but conditions of flexure soon supersede the question of crushing, and tend to complicate the simple inquiry; for no task could well seem more elementary than that of fixing the size of posts; yet the tendency to bend governs, and keeps within very close limitations, their applicability (whatever the sectional figure) as efficient vertical supports.

When it had been discovered that the power of a level beam increased with the square of the depth, it must have been seen that other rectilinear sections, obtainable from a given round tree, were stronger than the square, though of smaller area. A parallelogram, having for its least side one-half of a pentagon, was for a time accepted; but further investigation substituted a face of the hexagon as the breadth of the strongest obtainable beam from a given tree. But, discarding that maximum relation, the same strength is reached, with a further saving of wood, as shown in the table of joists.

Whether stress be exerted upon a horizontal girder, or upon an upright post, flexure ensues. It is generated in different ways, and with some variation of form, but is a common property, making the two cases less dissimilar than they at first appear. A cross-strain causes bending in the direction of that strain; compression at the ends acts upon the diagonal. But inasmuch as a thin board from the middle of a tree would have the same diagonal as the largest obtainable scantling, the only reliable measure of strength in a part is the area of its base, and, in a figure, yielding support to the axis with tolerable equability. The sectional area, or base of a post, may be found by the following rule: Multiply the pounds in the load by the decimal ·002; and the square root of the product multiplied by the height in feet gives the area in inches. Let it be required, for example, to sustain a weight of 20,000 lb. at a height of 20 ft.: $20{,}000 \times {\cdot}002 = 40$ $\sqrt{6{\cdot}3} \times 20 = 126$, which is the number of inches in the base or section of the post. A few other results with the same weight are set down, and it will be seen that they are in direct proportion to the height—if one be doubled, so is the other; but every change of load requires a fresh calculation.

WEIGHT TO BE SUPPORTED, 20,000 LB.

Height in feet.	Area in inches.	Diameter of Circular Post.	Side of Square Post.	Rectangle.	Effective Power per sq. in. in lb.
10	63	9	8	10 × 6¼	320
15	94½	11	9½	12½ × 7½	212
20	126	12½	11¼	14 × 9	160
25	157½	14	12½	16½ × 9½	128
30	189	15½	13¾	17½ × 11	107

Were the column of effective power here tentatively introduced, confirmed by experiment, as above suggested, it would be of great value, because applicable to every height and every load.

The resistance of fir to crushing, by pressure on the side, is so nearly equal to that at the ends that sills and bressummers are not injured by posts of proper size charged with appropriate loads.

The form in which timber is imported, and the mechanical methods of conversion, make right-lined sections economical and convenient. In the annexed diagrams the cylinder is supposed to be 10 in. diameter and the area 78 in. Inscribed

square, 50 in. Rectangle on pentagon base, 48. Ditto hexagon, 44. Heptagon, 40. Octagon, 37. (See Figs. 1 and 2.)

It appears so desirable that the behavior of posts with these several bases under compression should be generally known, and the question seems capable of determination by modern apparatus with so much facility and precision as to induce the wish that some scientific body may institute an experimental inquiry on the subject. It might well, indeed, embrace and exemplify, on a reliable scale, all strains by which a material of such universal application in building as fir timber is ordinarily affected, and whose economic use is a point of general concern. When structures fail the consequences are often calamitous, and the lesson they teach is that, instead of regarding tabulated data as ample, due addition should be made to compensate for incisions in the process of framing, and with the strongest propriety as regards posts partly in the earth, or otherwise in unfavorable situations, against the agencies of decay.

Piles are distinguishable from posts principally by their association with underworks and preparations rather than with superstructures, and they claim little attention from the carpenter; but it is worthy of remark that, for this subsidiary purpose, a tree of the lowest general estimation is pre-eminently fitted. Dr. Horman, whose English is less easily deciphered now, perhaps, than before the Reformation, says: "A quavery or mares and unstable foundacys must be holpe with great pyles of alder, ramed downe with a frame of tymbre called a crossaundre;" and every writer, from Vitruvius downward, pays the tribute of recognition to the merits of alder, when wholly in the earth or wholly under water. If merely damp it rots apace; if dry it is soon devoured by worms. Most of the fabrics of marshy Ravenna and the Rialto at Venice are based on piles of alder. Though soft, and in many ways so inferior to the oak, it is equal in toughness, and thus able to bear the percussive shock of the driving ram.

Fig. 1.

Fig. 2.

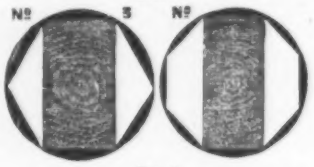
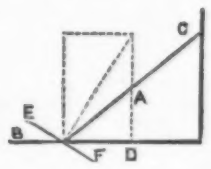


Fig. 3.

Fig. 4.



SHORES.

Shores are timbers used as props or temporary buttresses, for preventing injury to structures that are sound, or supporting such as are unsafe. The typical form is the oblique strut, called a "raking shore." Like the story post, it is in a state of compression, but, instead of acting as an erect bearer, it exerts a lateral thrust. It would do so with most powerful effect if set at an angle of about 40° with the horizon, but under the exigencies of fact the spread at the base is generally much less than would then be the case. The timber is often raised to an angle of 60°, or even 70°, at which last the height is upward of 2½ times as great as the spread of the foot, while hardly one-fifth of the force takes a horizontal direction. The operator, therefore, in fixing the scantling, must consider, not only the weight of the work to be supported, but the loss of power due to the effective direction. (See Fig. 3.)

The length, section, and slope of a shore being determined, an abutment is prepared at the top by an upright plank against the structure to be sustained. Through the plank is passed a strong stud that forms a projecting shoulder in front, and by penetrating the structure keeps the plank from sliding upward. The head of the shore is then adapted, and the timber driven up with the required force by means of wedges comprised in the foundation of planking at the ground level. Care is to be observed that the foot of the shore has a perfect and uniform bearing, so as to avoid the leverage and wasteful strain that ensues when the pressure is uneven. It may be pointed out that, when a timber is compressed at the ends, its ability to resist a cross-strain is impaired, and that consequently one shore should not be made a support for a second, as may too frequently be seen, but each should have its proper footing on the ground. The mechanics of shoring may be shortly stated with the help of Fig. 4. If a sloping timber, A, rest on the ground at the foot, and against a wall at the top, it will exert three forces. Were there no impediments it would descend in a vertical line, D, but, being prevented, it tends to slide along the ground, B, and, checked there, it seeks to overturn the wall, C. The pressure on the shore being uniform, the center of gravity is at the middle of the length, and the several strains may be thus estimated. If a vertical line be drawn through the center of gravity from the ground to the height of the shore, and that line be taken as the scale of the vertical pressure, the horizontal distance from the center of gravity to the foot of the shore will be the proportionate measure of the lateral thrust against the wall at the top and the sliding force on the ground. Then an inclined line from the top of the vertical ordinate to the foot of the shore will have a medium direction between the two forces acting on the ground, and the foundation should be made at right angles to that line, and not to the actual direction of the shore. It illustrates in a simple way the process known as the "composition of forces," with which the artist in carpentry should be familiar.—Thomas Morris, *in Building News.*

THE SEVERN RAILWAY BRIDGE.

Nine years have passed since the project for extending the dock accommodation at Sharpness on the Severn was seriously regarded as an enterprise in connection with the Gloucester and Berkeley Canal, extending from that point on the Severn to the city of Gloucester. The undertaking was likewise of importance with the view of affording shipping facilities for corn and timber. The canal had, no doubt, answered the expectations of its original promoters; but the trade of Gloucester has outgrown the facilities by which it was to be kept up. In practically dealing with the question, there was the necessity of extending the canal to afford, or rather secure, a better entry for the larger ships. The tidal basin at Sharpness was inadequate, and its site was not the most favorable. The work of improvement has been accomplished, and already the result is a largely extended trade and a colony of warehouses, shops, and hotels springing into existence, constituting a small town. Several schemes were launched for crossing the Severn, but the Severn Bridge embraces all the advantages contemplated—both by Brunel, at Hock Crib, and by the Newnham Bridge Company. In addition, it realizes more important advantages still in reaching Sharpness, more particularly in respect to a possible export trade, both for Dean Forest in coal and iron, and the Midland Counties in these and other commodities. To South Wales the Severn Bridge scheme is, perhaps, of equal importance. In Dean Forest, millions of tons, both of iron ore and coal, have been locked up, so to speak, because of difficulties more directly traceable to inefficient outlets than to the absence of a spirit of enterprise. Within the past few years the Severn and Wye railway directors have constructed their branch railways to intersect the Forest coalfield, which must eventually prove commercially valuable. About five years since an act was obtained for the construction of the Severn Bridge. At that time all branches of industry were in a most inflated and unnatural position, and the directors thought it prudent to withhold their contracts until the labor market was restored to something like an equitable basis. The contracts were let at the beginning of 1875, viz., to the Hamilton's Windsor Iron Company, Liverpool, for the bridge, at £190,000; and the railway with masonry work, to Messrs. Vickers and Cooke, of London, at £30,000. Starting from the Forest of Dean, the railway connects itself with the Severn and Wye Railway, and the Great Western Railway, at Lydney, about three miles distant. The approach to the bridge is made by means of a viaduct, consisting of twelve arches, to be carried 70 feet high, of Forest rock masonry. The immense blocks of Forest stone brought into requisition are remarkable for their excellence of quality and solidity. By the courtesy of Mr. Earle, the resident manager of the Hamilton's Windsor Iron Company, our correspondent has been enabled to inspect the bridge works, which are now progressing with rapidity. On the Forest shore the first span is 134 feet, the piers of which are being founded. There are four of these in a cluster, each cylinder having to be taken 16 feet in the solid rock. An engine and air pressure apparatus is employed for this purpose; and, in addition to the cylinders themselves, each lift of four feet in height being over five tons in weight, some 70 tons of ballast is required upon each column to counteract the pressure of the air to displace the water from the interior. The air-bell consists of a chamber 5 feet in diameter, built with ordinary boiler plates; on one side is an ante-chamber, into which the sinkers are admitted, and then they descend to the working, still under pressure up to 28 lb. to the inch, with perfect safety. This great pressure does not appear to have an injurious effect upon the persons employed; those who commenced some eighteen months ago at the outset of the sinking operations appear to enjoy good health. The work of placing these columns is now being proceeded with. The spans run as follows:—One 134 feet, two 327 feet, five 171 feet, and thirteen 134 feet. The two principal spans are on the Forest shore, and across the navigable channel, with headway of 70 feet above high water, and ordinary spring-tides, but scarcely reaching that height upon Sunday last, when the tide was the highest of the year. There is a gradual decrease of the headway to 50 feet. Each of the piers for the 327-feet spans will consist of the group of cylinders before named, with 10 feet diameter, and they are to be founded 44 feet below low-water mark. The remaining piers will be constructed of two cylinders of somewhat less capacity, and the founding of these will likewise vary from 42 feet to 15 feet below low water-mark. Great as the two principal spans are, they are less by 133 feet than the Britannia Tubular Bridge, which carries, by a series of four spans, the Chester and Holyhead Railway across the Menai Straits. Seventeen piers have been founded in the bed of the Severn, and so far the work has been carried out without accident to the persons employed. The whole of the 134 feet spans are erected, and the scaffolding is nearly prepared for the first of the 171-feet spans, and the foundations are completed and the piers finished for three of these. The spans are raised in pieces from the vessels by a "Goliath," constructed with a double carriage to ensure strength and safety, the principal supports running outside of the girders. This massive machinery is rendered movable by being so constructed as to run on a single line of rails fixed, as already stated, outside the bridge. The extreme height to which these girders are to be lifted is 80 feet above low-water mark. About two-thirds of the Severn has been spanned, and everything over that distance is ready for the laying of the permanent way. The provision made in respect to expansion and contraction of the girders is as follows:—One end is secured upon a plate of cast-iron, bound to a large block of Forest stone, and the other end is connected on a system of rollers to permit of expansion, space being left at the end of each girder to meet the action of the atmospheric influences. The columns are filled with concrete, composed of three parts of Forest furnace slag, from Parkend, and the other part of Abethaw lime. Taking one of the lesser piers, for instance No. 16, there would be nearly 400 tons concrete in the two columns; the larger ones, 19 and 20, will take something approaching double that quantity. The view from the bridge is possibly unequalled in picturesque beauty.

Another striking feature of the undertaking is the swing bridge over the old canal. The centre will be supported from an extensive round tower constructed of Forest stone with immense capping. This tower stands midway of the towing path. The extreme ends will be supported by masonry of the same character as the viaduct on the Forest shore. All the materials for this bridge have been delivered, and the directors recently arranged to construct a double roadway over the canal, in order that no interference should arise with regard to the traffic, should it be found necessary at any future time to widen the Severn bridge proper. This swing-bridge will be worked by steam—a novelty in this part of the country for moving such structures. The engine is to be in the centre, and to this circumstance, together with the width of the canal bridge, it is to be ascribed that the masonry—more especially that of the tower—possesses so much solidity and extensive proportions.

The Severn Bridge, as a whole, will show massive spans of ironwork, rivetted plates, prepared with mathematical exactness of detail, and supported upon piers apparently light, and yet of much solidity and beauty. The engineers who promoted the scheme, designed the structure, and are now carrying on the works, are Mr. G. W. Keeling, M. Inst. C. E., Lydney, Gloucestershire, and Mr. George Wells Owen, C. E., Westminster. The consulting engineer is Mr. Thos. E. Harrison, President Inst. C. E., and Mr. Reichenbach is resident engineer.

SLIPPING OF LOCOMOTIVE WHEELS.

A French engineer, M. Rabeuf, has lately been led to study the phenomenon of slipping of wheels of locomotives, which appears to be a more general and complex phenomenon than has been supposed hitherto. He observed, in going down an incline of 0·005 in a metre, with a speed of 120 kilometres per hour, that the real velocity of the coupled wheels was 360 turns per minute, instead of 303 turns, which would correspond to the rate of translation. He finds from further inquiry that the slipping is almost nil in ascending an incline, but that it is always very notable in descending. It increases very rapidly with the speed, but appears to be greater, for the same velocity, in descents than in ascents. Its suppression, if possible, would cause a considerable economy in consumption of fuel and in wear of machinery.

THE COMBINATION SHAFT.

ONE OF THE GREAT MINING PROJECTS OF THE DAY.

The Chollar-Norcross-Savage shaft, or, as it is more generally called, the Combination shaft, is now nearing the level of the Sutro tunnel. So near each other have the workings of these two great mining projects come, says the Gold Hill *News*, that the blasts in the tunnel are distinctly heard by the workmen in the shaft. Nor is this very wonderful when it is considered that here remain only about 1,050 feet of rock between the two points, and that the charges used in the tunnel are very heavy, several in number and all exploded at the same instant of time by electric exploders. The discharges of blasts in the Combination shaft are also distinctly heard in the east drift, 1800-foot level, of the Chollar-Potosi, the distance between the two points being 900 feet. The tunnel line, it will be remembered, however, iis 950 feet north of the shaft.

A GREAT MINING PROJECT.

Every day shows more conclusively the wisdom of going half a mile east of the main line of the present hoisting works of the Comstock and of sinking a monster shaft perpendicularly to the ledge. Should the general dip of the Comstock be maintained to greater depths, this monster shaft will strike the vein about 2,800 feet from the surface. The same wisdom which conceived the project is being exemplified in carrying it on. Everything is on a scale commensurate with the undertaking itself. Before a spade or pick was struck to even grade off the locality of the present works, preparations for convenient access were made, and a side track from the Virginia and Truckee railroad and a wagon road to the site projected. Then commenced the grand preparations, the plans of which had all been fully matured by I. L. Requa, the chosen Superintendent of the shaft.

THE SITE, SHAFT, WORKS, ETC.

The site selected for the shaft was a most eligible one. From it the view of the city is particularly fine. It stands some 200 feet above the bottom of the ravine, and has dump room sufficient for years. The site having been determined upon, a double grade was made, the upper one of about three acres, for the hoisting works proper, and the lower one for the shaft, blacksmith and carpenter shops, etc. The shaft, which was started on the lower grade, is the largest and finest on the lode. The actual excavation is 10 feet 6 inches by 30 feet 6 inches. The shaft, when timbered by 14 by 14 timbers of spruce, has four compartments, three being 5 by 6 in the clear, and the fourth, or pump compartment, being 6 by 7 feet. Its depth is now about 1,550 feet. The main building is 60 by 140 feet, 20 feet high, and contains the hoisting and pumping engines. The room is well lighted and easy of access, being on the upper grade, and reached by both wagon road and side track. It extends over the shaft room and affords ample space for offices when needed at the works.

THE SHAFT ROOM AND SHOPS

are situated on the lower grade. The former is 40 by 60 feet and 32 feet high, that being the difference in altitude of the two grades. The east side of the room is the wall extending from the lower to the upper grade. This wall is 8 feet in thickness at the bottom, 32 feet high, and built of hewn granite. It contains four vertical piers, and is pierced for the shaft end of the pump bob. The carpenter shop is at the southwest corner of the shaft room, is 40 by 80 feet, 16 feet high, and fitted up with the usual facilities for preparing timbers, etc. The machine is run by a 35 horse-power engine.

The timbers, etc., are all dumped from the upper grade, right where wanted. The blacksmith shop is at the west end of the main structure, is 30 by 60 feet, and 20 feet high. It contains two forges driven by a blower. The drying room is south of the main building, and is 30 by 50 feet. The

boiler room is north of the main building, is 40 by 50 feet, and 20 feet high, and contains two sets of largest-size boilers.

THE MACHINERY

is first-class in every respect. The hoisting engine is geared to 350 horse-power, and is sufficient to do the required work after the lode is reached as well as before. It turns two reels, on each of which are wound 2,900 feet of cable six inches wide and five-eighths of an inch thick. Near the hoisting engine is a double-geared steam winch, or pump-hoist, capable of lifting 80 tons. It moves slowly and strongly, from 60 to 70 feet per minute being its most rapid movements. It has windlass heads on each end, and is used by means of a snatch-block for moving heavy objects anywhere about the building. The cable attached is seven inches by five-eighths of an inch, and made by Hallidie & Co., San Francisco, of the best steel wires. It has the strength to handle the pumps to the depth of 3,500 feet.

THE PUMPING APPARATUS

is second to none on the lode. It stands near the shaft and has never been used, there being very little water in the shaft. It is, however, all ready to run, and is a vertical compound condenser of 700-horse power, capable of running a double column of 12 inch, 8-feet plunger pumps to any required depth. It is controlled by the Davy differential valve, and can make one stroke in 15 minutes, or 12 strokes in one minute. It is attached directly to the bishop head of the bob. The initial cylinder is 32 inches by 10 feet stroke, the expansion cylinder is 64 inches by 8 feet stroke. The engines, pumps, and bob weighs 150 tons. The beam of the bob is all iron and weighs 52 tons. There are ten sticks for pump rods on hand, each 15 by 15 and 100 feet long, Oregon pine, and cost here $300 each. They are the finest sticks ever seen on the Comstock, being as straight as arrows and of the clear stuff. The joints at the ends of these as they go together to form the rod will be cut square and oak keys fitted and driven in so as to make all as solid as the native stick. These joints will be still more firmly secured by iron straps 10 inches wide, 1 inch thick, and 36 feet long, one on each side. These sticks are all numbered and bored, and the plates are also numbered and perforated to correspond. In the side of the shaft room panel doors have been placed, and, above a section of the floor, made movable for the purpose of handling these sticks for pump rods. The pumps are all on hand ready to be put in.

THE SHEAVES, SKEET, ETC.

The sheaves and the construction of the gallows frame are unique and worthy of particular mention. The frame is built upon the top of the stone wall above mentioned. The sheaves are 18 feet in diameter, and so set as to carry the cable over to the center of the shaft below. The faces of the sheaves are eight and a half inches wide, filled with oak wood to prevent crystallization. They are so constructed as to stand the strain of 100 tons each. At the end of the cable, instead of a cage, is found a skeet, an excellent invention of Mr. Requa, capable of holding five tons of rock, and which dispenses with all station tenders, as by an ingenious contrivance it dumps and rights itself. It saves the handling of an immense amount of dead weight. It is still now most of the time, but brings up 100 tons of rock and 16,000 gallons of water daily, and there are required to run all the saws, machinery, etc., and do this work with only 20 cords of wood per week. When the works are all completed and in running order, and three of these skeets used, 2,000 tons of rock can be raised per day.

MISCELLANEOUS MENTION.

This shaft is situated 2,327 feet east of the Chollar-Potosi shaft. It was recently plumbed and found to be one-quarter of an inch out of the way north and south, and one-half an inch east and west, which shows what kind of work Mr. Requa is doing. It is so smooth and straight that the skeets pass up and down without bearing against the guide. The general arrangement of the works is as perfect as any on the lode, and was all planned by Mr. Requa. In bringing the pump rods from San Francisco they were loaded on four flat cars, the weight, however, being borne principally by the end cars. In this manner all the twists and turns of the railroad were made in safety. The rope house is 200 feet east of the main building, so that in case of fire the works will not be endangered. The company owns 35 acres of land where the works are situated, and every time the place is visited, the wisdom of the undertaking, and the excellence of the arrangements made by Mr. Requa to carry it out, are made more and more apparent.

ROCK-BORING MACHINERY.

THE MOONTA COMPRESSOR.—This compressor is designed to run at a high or low speed, and to furnish a satisfactory proportion of power for the unit of steam power expended. In general it is not unlike the Colladon and Blanzy compressors, but it differs in the one case in the piston and rod, which are solid instead of being hollow, and in the other by the employment of gun metal instead of leather valves. The internal cylinder, *A*, of brass, for the Moonta Mines, South Australia, is surrounded by a cast-iron cylinder, *B*. Through the annular space, E, a constant flow of water is maintained.

In each cover is inserted water jets, *C C*, also one inlet and two outlet valves. The seatings of the inlet valves are shown, not the valves themselves; the bonnets outside of the valves are also removed. The outlet pipe, D, is placed at the bottom of the cylinder.

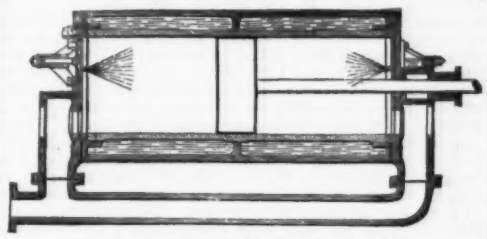
For the purpose of forcing water into the cylinder and dividing the water into fine spray, no matter what the tension of the air may be, a small hydraulic accumulator is employed. The engine driving the compressor is provided with steam and expansion valve; the latter so arranged as to be instantly varied during the running of the piston. One of these compressors is erected at the Foxdale Mines, Isle of Man, but at that place the spray jet is to be maintained by means of an air vessel. A third is nearly complete for Wheal Agar, Cornwall.

	Moonta.	Foxdale.	Wheal Agar.
Diameter of air pump	13 in.	20 in.	18 in.
Length of stroke.....	36 in.	48 in.	60 in.

THE FLOWER COMPRESSOR.—At the Powell Duffryn Collieries, South Wales, a large compressing engine is erected. The steam cylinders driving the compressors are coupled together at right angles, and have 34 in. steam and 40 in. air cylinders, the stroke being 6 ft. The steam at a pressure of 70 lbs. per square inch is cut off at ¼ stroke, while the air is compressed to 40 lbs. per inch. The inlet valves, three in each cylinder cover of the air cylinders, are of cast iron with leather flaps. The outlet valves, two in each cover, are of brass, with mitre faces 1¼ in. long, inclined at an angle of 30° to the valve spindle. Each air cylinder is set in a trough of water, but no spray jet is forced into the interior during the compression of the air. The engines at 20 revolutions, or at a piston speed of 240 ft. per minute, indicate 483 horse power.

Area of air cylinder	1,256 inches.
Contents of stroke	104·6 cub. ft.
Contents per minute.....	4,185 "
" at 67 per cent. of the stroke,	2,804 "
Compressed to 45 lbs. per inch ..	934 "
Area of three inlet valves..... ..	64·8 sq. in.
Area of two outlet valves..... ..	43·2 "

FESTINIOG TUNNEL.—The compressors in use in this tunnel are mounted on the receiver. The air cylinders surrounded with water, double acting, 16 in. diameter and 30 in. stroke. At a speed of 60 revolutions per minute sufficient air is compressed to run two drills, the cylinders of which are 4 in. diameter.



THE MOONTA AIR COMPRESSOR.

The cost of compressing machinery may be regarded at present as a great drawback to the rapid introduction of rock drills. As in all new and important inventions, many parts and details are subject to modification and improvement. At the same time men must be educated in the use of new appliances.

In addition, prejudice, ignorance, and misrepresentation of facts have to be disposed of—not by argument or verbal assertions, but by positive success, not more strictly of a technical than of a money character. There are now many people skilled in the running of rock-boring machines, so that success is becoming a rule, not an exception. Still, in a period of transition from one condition of things to another, the outlay of a serious sum of money must in many instances be cautiously and doubtfully undertaken. The double Sommeiller compressor at Blanzy Mines, with boilers, air receivers, and buildings, cost 6,000*l*. The Cockerill Foundry, near Liége, supply a pair of twin engines and compressors, sufficient to drive four to six of the Dubois and François borers, without boilers or connections, for 1,000*l*. At the Anzen Mines, in France, a double compressor cylinder, 18 in. diameter and 4½ ft. stroke, with two receivers, connections, and foundations complete, cost 2,080*l*. At Ronchamp, where a Sommeiller compressor was attached to an engine and boiler previously erected, the cost, including an air receiver having a capacity of 880 cubic ft., was 1,235*l*. At Minera a double 10½ in. cylinder compressor engine, two 10 in. compressors, 30 in. stroke, irrespective of boiler and erection, cost about 350*l*.

Colladon's compressors are made in four distinct sizes, No. 2 being sufficiently powerful when worked at a maximum velocity to run four of McKean's 3½ in. cylinder machines, the cost of engine and compressor complete being 1,512*l*.

The objections which may be urged against high-speed compressors are: 1. The rapidity with which heat is accumulated within the cylinder, frequently overheating the various parts connected with it. 2. Loss of air with dry metallic spring pistons amounting from 7 to 10 per cent. of the stroke and increasing largely with low piston velocities. 3. The voidance of air from the cylinder during the closing of the inlet valves; in some cases a serious percentage of the contents of the stroke. 4. The loss of useful effect of the steam, consequent on the passage of air from front to back of spring-ring pistons, and on the voidance of air from the cylinder. 5. The rapid wear and tear of parts incident to a high piston speed, and the increasing attention necessary on the part of the machinist to keep the moving surfaces correct, one with another, as the use of the apparatus lengthens. 6. The liability of the valves to breakage, the force or impact of the shutting blow increasing with the pressure multiplied by the square of the velocity. Against low speed wet compressors, it may be alleged that the piston speed is low, the apparatus large in proportion to the power it will afford, and that the first cost, if distributed on the horse-power of the compressor, is exceedingly high.

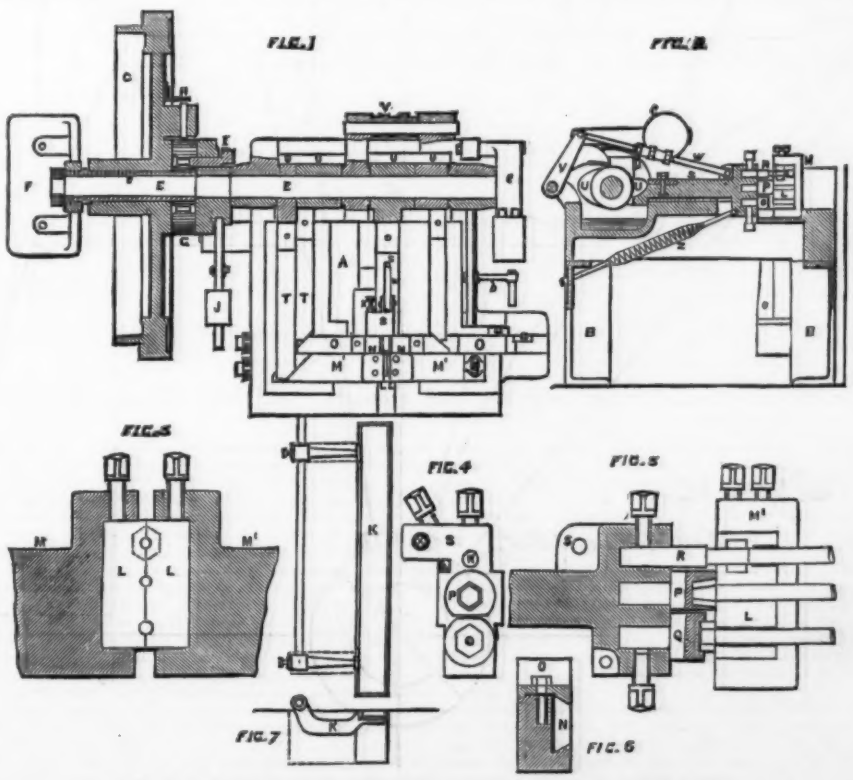
In mines, simplicity and certainty of action of the mechanical appliances is of the highest moment. Many undertakings cannot incur the expense of retaining the services of a skilled engineer and one or two mechanics, and hence, however excellent a machine may be, if its parts are complicated, necessitating extreme care and watchfulness in their use, the whole are likely to fail. Again, when the mine cost month after month, extending perhaps into years, is derived from a body of shareholders, in many instances barely able to sustain their contributions, it is of considerable moment that the mechanical appliances should combine economy with strength and simplicity. In the Sommeiller water-compressor, Gralliot's experiments showed that only 35 per cent. of the boiler power was charged into the receiver, and only 20 to 25 per cent. of the boiler horse-power obtained in the boring machines.

At Altenberg, the Prussian engineers entrapped, as it were, into the cylinder of a wet compressor, 96 per cent. of the volume due to the stroke. At St. Gothard, the Colladon compressors are reckoned to compress a volume of air equal to 70 per cent. of the stroke. Now, if the equivalent of a boiler horse-power in a high-pressure engine is 6 lbs. of coal per hour, it follows that a horse-power in the receiver is represented by about 18 lbs. of coal, and in the boring machine by 24 lbs. of coal per hour. If, however, only 70 parts of air per stroke is obtained against 96 in the compressor, the weight of coal per horse power in the receiver will be increased to 24½ lbs., and in the boring machine to near 33 lbs. per horse-power per hour. With wet pumps, overheating of the air and the cylinder takes place only in a very minor degree, the temperature reaching at the utmost only from 77° to 80° Fahr., whilst with dry pumps the temperature at high velocities and pressures reaches 175° Fah. —*John Dablington, in Mining Journal.*

NUT AND BOLT FORGING MACHINE

OUR illustrations show the ingenious machine for forging bolts and nuts, known as Horsfall's patent, as manufactured by Greenwood and Batley, Leeds, Eng.

Fig. 1 is a sectional plan; Fig. 2 is a vertical section through the header slide and gripping dies; Figs. 3,4,5,6, and 7 are details to an enlarged scale. A is the bed of the machine; O is the driving pulley, which revolves on a stationary socket D. The cam shaft E revolves inside the socket D, and the outer end of the socket is supported by a bracket F. The boss G is driven by a breaker pin H—*i. e.*, a pin of cast iron, which breaks before any dangerous strain is thrown on the parts of the machine in working—carried by the driving pulley. On the face of the boss G are recesses for a clutch pin, I being the clutch box, which is keyed on to the cam shaft E. The clutch is controlled by the attendant by means of the lever J and treadle-board K. L L, Fig. 3, are gripping dies, carried in slides M M¹, and N N are side hammers carried by the slides O O, and, like the slides M, operated by the cams and the sliding pieces T. P, Figs, 2 and 5, is the first operation, or bunting tool; Q is the second operation, or flattening tool; and R is the punch for nuts. The tools P, Q, R are carried by the header slide S. Motion is transmitted to the gripping slide M, and to the slide hammer slides O O, by means of the slides T T. Cast steel tail-pieces are fixed to the end of slides T, T, T, and S, to work against the cam U U U U on the cam shaft E. The header slide S is partly withdrawn by lever V and connecting rod W; the remainder of its backward motion to the stop screw X, Fig. 1, is completed by the spiral spring Z, Fig. 2. X is an adjustable stop for regulating the quantity of iron standing out in front of the gripping dies L L. Cutting-off shears are



MACHINE FOR FORGING NUTS AND BOLTS.

shown at *a a*, Fig. 1, and *b* is an adjustable gauge for cutting bolts to length. The slides M and O O are withdrawn by springs *c*, *c*, *c*, Fig. 2. These springs may also be seen at Fig. 1 near the lever J. A breaker piece *r* is placed behind the gripping slide M, so that if a piece of iron of too large a size is gripped, or gets across the dies, this breaks before any damage is done to the machine.

The speed for working the machine is fifty and seventy revolutions per minute. The ends of bars on which heads or nuts are to be formed must be brought to a welding heat. The first operation in making nuts or bolts is performed by he middle or bunting tool P Fig. 5, the bar being passed into and held by the grippers L, one revolution being required. After this the iron is moved from the middle to the lower hole in the dies, and two or more revolutions given for bringing the head or nut from the form of P to that of Q. After the heads are formed, bolts can be cut to any required length up to 23in. in the machine by the shears *a a*. Longer bolts must be cut off before the heads are formed. Hexagon and square nuts are formed on the end of a bar exactly in the same manner as in making a bolt, the nuts being punched in the upper hole in the gripping dies by the punch R. The punching is left on the bar, and will go into the next nut made. When making bolts with mushroom countersunk rivets or spike heads, the side hammers are not required. The machine is set in motion by pressing the foot on the treadle-board K, which thus engages the clutch with the main wheel.—*The Engineer.*

To protect polished steel from rust use pure paraffine. The latter should be warmed, rubbed on, and then wiped off with a woolen rag.

A good black paint for coarse iron work may be made by mixing plumbago with hot coal tar.

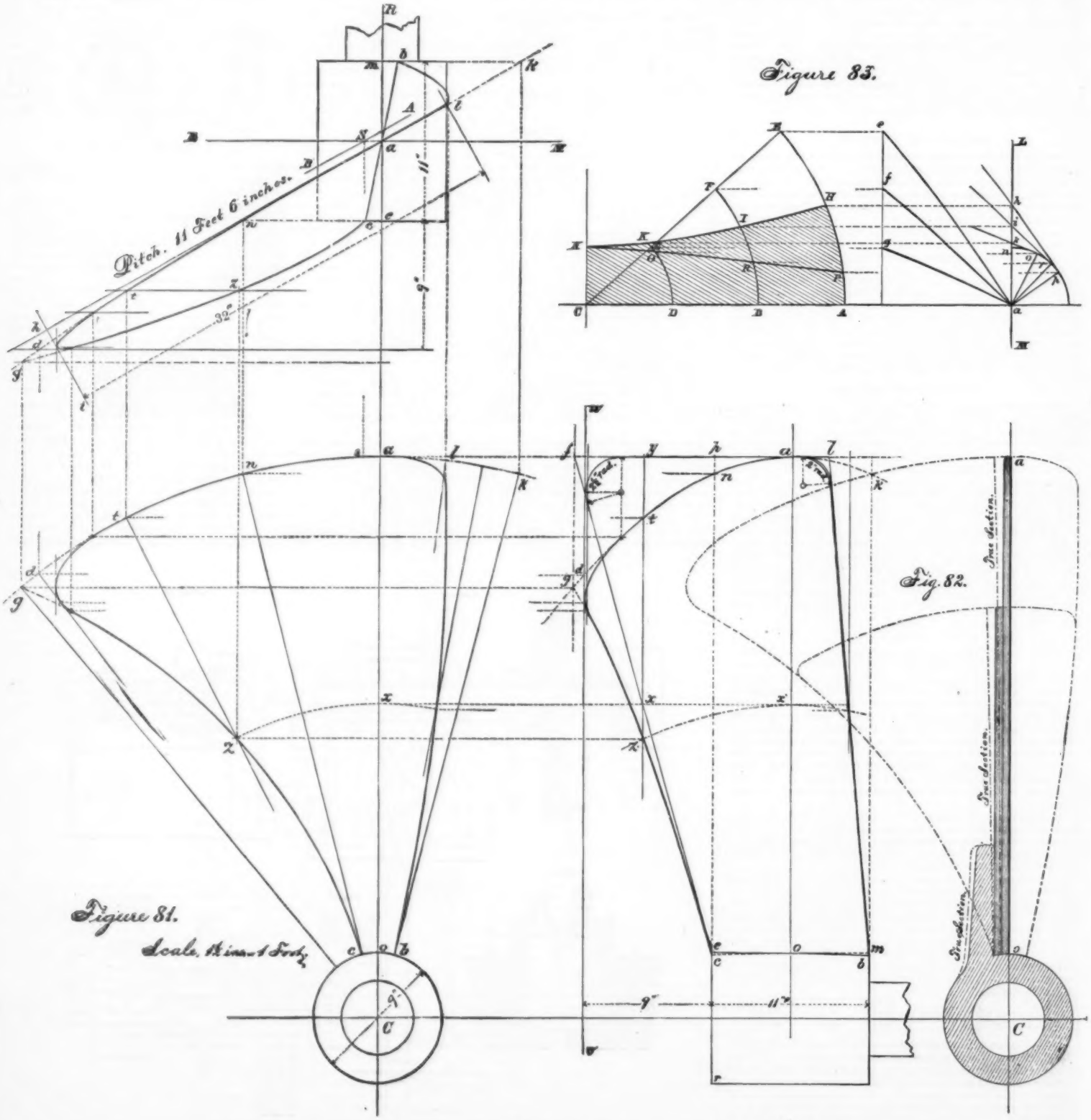
LESSONS IN MECHANICAL DRAWING.

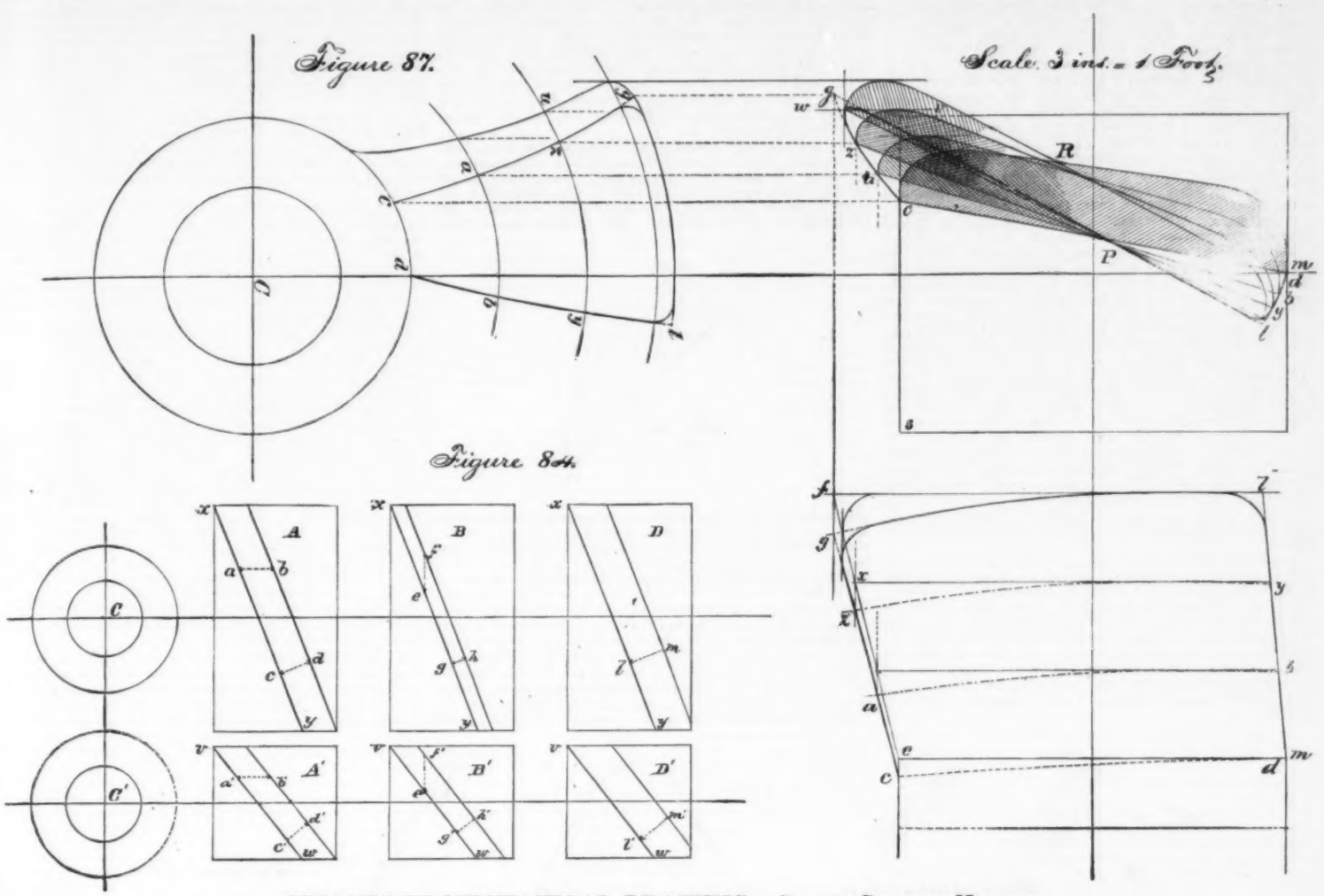
By Prof. C. W. MacCord.

Second Series, No. xiii.

On the Screw Propeller, Continued,

We propose now to make a complete drawing of a wrought iron propeller blade, constructed in the manner described in the last lesson. The first thing is of course to lay out the elementary blade or acting surface, and in order to avoid confusion we show this process in a separate diagram, Fig. 81. The hub is 9 inches in diameter, 11 inches long, and cylindrical; its outlines are first drawn, and the helix on its surface is next to be determined. As a starting point, it is usual to assume that the element of the screw-blade located at the middle of the length of the hub is either vertical or horizontal, according to the position in which it is most convenient to make the drawing: if there be four blades, this element in one would be vertical, and in the other horizontal, so that, the side view of one blade being identical with the top view of the other, only two views of the propeller need be drawn, instances of which have appeared in preceding figures. In the present case, however, as we represent but one blade, we give three views, and assume the element referred to in a vertical position, so that in the top view it appears as the point *a*. The pitch is 11 feet 6 inches; this being known, the helix on the hub, *b c*, is now drawn. The diameter of the outer rim is 6 feet 6 inches, which information enables us to draw an indefinite helix through *a*, of which a part will be the outer edge of the blade. This is now to be limited, which in this instance is done as follows. It is specified in the first place that there is to be an overhang of 9 inches on the aft side, *after* the corner of the outline swept out by the screw in revolving is rounded off by a circular arc of 2½ inches radius. We therefore proceed thus; draw in the side view a horizontal line through *a*, a vertical line *w v*, 9 inches aft of the after end of the hub; tangent to these lines an arc with the given radius, and from *e* a right line tangent to this arc; this line it is better to produce, to cut the horizontal line through *a* in the point *f*, which would be the highest position occupied by the trailing point of the blade were the corner not rounded off. A perpendicular through *f* will give the projection of this point on the blade by its intersection *g* with the side view of the helix through *a*, previously drawn, which may then be projected to *g* in the side view, and thence to the helix in the top view. Or we may draw in the top view a parallel to *L M*, at a distance from it equal to *a f* in the side view, and thus determine *g*. This extension of the blade to the outer limit is advised, as conducive to greater accuracy; the matter of the rounding off of the corners having been previously explained, we show merely the result. The trailing edge being thus determined, we come to the consideration of the leading one. It is clear that this might be limited in the same way, and it is sometimes so done; if it be, it will also be seen that the length of the arc of the outer helix, and consequently the breadth of the blade at its exterior edge, will be thereby fixed. Instead of this, however, it is very common for the designer to stipulate that, in addition to a specified overhang on the aft side, the blade should have a given breadth at the periphery. And this breadth it is very common to give in the manner shown in the top view: *a h*, tangent to the helix at *a*, is first drawn, then *h i* perpendicular to *a h* and tangent to the curve of the rounded corner, previously determined: from this perpendicular is drawn the dimension line parallel to *a h*, and of the given length; finally, at the extremity of this, another line, perpendicular to *a h*, cuts the helix at *l*. Then measuring the distance of this point from *L M*, set off *a l* in the side view equal to it, and draw *l m*. This would fix the point of the leading edge were the corner not to be rounded off: supposing that this is to be done, we have now only to draw with the given radius, in this case 2 inches, an arc tangent to *f l* and *l m*, find the





LESSONS IN MECHANICAL DRAWING. SECOND SERIES. No. 13.

points of tangency, and complete the drawing of the blade in the manner previously explained. It will be observed that when the breadth of the blade is given in this manner, it is impossible to assume the rounding of both corners, since, if for instance the curve of the aft one be fixed, as we have supposed, thus locating f then the position of l, and therefore the inclination of $l\,m$, depends upon that. But the effect of the rounding off of the leading corner upon the area of the blade is very trifling, so that this mode of fixing the breadth is practically as good as any.

Before going farther, we would call attention to a special manipulation in constructing the curve of the trailing edge of the blade. This operation, as explained in lesson XI, depends upon the intersections, in the side view, of the inclined line $f\,e$ with certain vertical lines, such as $y\,z$, Fig. 81; these verticals representing planes perpendicular to the axis, and also the elements of the helicoid which lie in those planes. Now, $f\,e$ may cut $y\,z$ at so acute an angle as to render the determination of the exact point of intersection difficult and the result unreliable: for which reason we will proceed thus.

lines more acutely than $f\,e$, so that the practical advantage of this method is there still more conspicuous: and $a\,o$ being once subdivided, it takes very little longer to determine both curves than one alone. It will be noted that these curves in the end view are both Archimedean spirals, the subdivisions of $a\,o$ being proportional to those of the arcs $n\,o$ and $l\,k$.

Now, in Fig. 82 is given a view which is very useful as conveying a clear idea of what is required; we have made it a separate figure, in order not to confuse our other diagrams, in which the construction lines must be clearly shown, though it is usual to draw this on the end view in the working plan, which in many cases is not objectionable, since the construction lines are not preserved, so that no confusion arises: this arrangement, we have indicated by dotting in the outline of the blade. In this figure, the vertical line $C\,a$ is, of course, the original vertical element of the acting surface: since the first plate is to be of uniform thickness, it is shown in section of that thickness, that is, bounded at the back by another vertical line; back of this is to be placed another plate, whose thickness is shown in the same way;

plane $L\,M$ at S, which is projected to L in the end view

Now it is a very common error to suppose that a line parallel to $a\,o$, through the point L, will be a correct section of the back of a blade of uniform thickness, by the plane $L\,M$. As nothing is more likely to correct this error than to make a practical test of that supposition, we have taken the pains to do so. Of course, if the supposition be correct, it will make no difference whether the assumed thickness be great or small, and for the purpose of clearly exhibiting the mode of operation, we have in Fig. 83 greatly exaggerated this dimension. As in Fig. 80, the sector of which C is the centre, represents a portion of a helicoid, and the quadrant whose centre is a, represents in the side view the curve which generates the back of the blade; this curve is seen in the end view as $N\,P$. $L\,M$ is a plane perpendicular to the axis, cutting the helicoid in the element $C\,A$: the arc $A\,E$ being the rim of the blade, appears in the side view as $a\,e$, the projection of a helix. $A\,E$ cuts $N\,P$ in P, which, projected to the quadrant at p, gives the point which describes a helix similar to $a\,e$, lying on a cylinder whose radius is $C\,A$.

LESSONS IN MECHANICAL DRAWING. SECOND SERIES. No. 13.

Draw a vertical plane through $e\,r$, the after end of the hub; this plane cuts the helix through a in n, and the line $f\,l$ in p. In the top view this plane will be seen as the horizontal line $c\,n$, cutting the helix in n, which, projected to the circle of the rim, locates n, in the end view below. Then $p\,f$ is the axial advance corresponding to the arc of rotation $n\,g$. Bisect this arc, and draw a radius through the point of bisection; this will represent an element midway between p and f in the side view, whence, bisecting $p\,f$ in y and drawing the vertical line $y\,z$, this latter line must *bisect* $f\,e$ in x, from which z is determined as previously explained. Consequently we may subdivide $p\,f$ and the arc $n\,g$ into the same number of equal parts, drawing the verticals and the radii, but we do not depend upon the intersections with $f\,e$, which may be independently subdivided. Even this however is not necessary, for it will be observed that x in the end view bisects $a\,o$, We may therefore at once subdivide $a\,o$ into as many equal parts as we do the arc $n\,g$, and make use of these subdivisions in determining the curve $c\,z\,g$. A similar construction and argument, of course, apply equally well to the curve of the leading edge; indeed, the overhang being usually less on the forward than on the aft side, $l\,m$ will cut the vertical

and finally, the projection on the hub, which is not uniformly thick, but thinner at the periphery than at the junction with the hub, is drawn with the desired taper.

This, we say, is very explanatory: but it must be clearly understood that it is not an exact section of the screw by any plane, nor in fact by any surface, as it can be seen in any projection. This we mention with emphasis, because its location on the end view would naturally lead one at first sight to suppose it intended to be a true section, and indeed we have reason to believe that many think it is one.

What it does show,—and herein lies its utility,—is the true *normal* thickness of the blade and of the lip on the hub, all along the central element $C\,a$. It is as though the series of normals to the acting face, drawn at different points of that element, were all revolved about a in the top view of Fig. 81, until they come into the vertical plane there seen edgewise as the line $L\,M$, so that in the end view they may appear of their true length.

In the top view in Fig. 81, $A\,B$ is a portion of the helix described on the outer cylinder of the screw, which represents the back of the blade at the edge, the assumed thickness of the plate being half an inch. This helix is cut by the

The plane $L\,M$ cuts this helix in h, which, projected to $A\,E$ produced, gives H, a point in the proposed section. The circle through D is the outline of a smaller cylinder, cutting $N\,P$ in O, and $C\,E$ in G: from which by a similar operation we find the helices $a\,g$, $o\,k$, of which the latter is cut by $L\,M$ in k, whence as before we determine K. And so of intermediate points, of which I is one, giving finally the curve $N\,H$ as the true section of the back of the blade, whose normal thickness is $a\,p$, by the plane $L\,M$.

It is very true that this curve will vary with different conditions; but in order to show the amount of the variation of the true section from the conventional one, in the case in hand, we have constructed the curves upon the assumed data of pitch and thickness, and drawn them in dotted lines in Fig. 82.

Probably, a misconception of the true state of things, similar to that which leads many to think that in a square-threaded screw the normal thickness of the thread is constant, lies at the root of the error above mentioned. If we cut the helicoid by a plane perpendicular to the axis, we have an element, as $C\,a$ in Fig. 82; and it seems at first sight very plausible to say, that if the right line parallel to it,

there shown as the back of the plate, moves with that element, retaining its position in relation to it throughout, the blade thus formed will be of uniform thickness, the back being always parallel to the front. It is true that it will be, if cut by a plane perpendicular to the axis; and every point in the parallel line described a helix, too. But the error perhaps will be made clearer by the aid of the diagrams given in Fig 84. The two circles whose center is *C*, are the inner and outer cylinders of a screw; at *A* are shown the developments of two adjacent helices, which are the outer edges of a thread of a common square-threaded screw: at *A'* we have the corresponding inner helices developed. In both cases the distances *a b*, *a' b'*, between the developments, measured in the direction of the axis, are the same; but the perpendicular distance *c' d'* is less than *c d*, showing that the thread becomes thinner as we approach the axis. At *B*, *B'*, is shown a similar construction, in the case of a thread of which the edge, *xy*, is the same as *xy* in the preceding case, but the back is formed by the motion of a line parallel to the element of the helicoidal screw-face, as above suggested. Here the *transverse* distances, *ef*, *e' f'*, are equal, but the perpendicular distance, *gh*, is less than *g' h'*: that is, the thread, as may have been already inferred, becomes *thicker* as we approach the center. And finally, at *D*, *D'*, we have given similar developments in the case of a thread of constant *normal* thickness the form of the generatrix of the back of which has been described. As before remarked, the perpendicular distances between these helices do not *exactly* measure the normal thickness in either case, because the helices lie on the surfaces of the cylinders, while the normals lie in planes tangent to them. Still, if these perpendiculars diminish or increase the normals will do the same, so that the diagrams illustrate the difference between the three cases sufficiently well, and clearly show thatif either the longitudinal, the transverse, or the normal thic ness be uniform, the other two will vary.

In determining the true section of the lip on the hub, the general method of operation is exactly the same in principle as in the case of the blade itself, but inasmuch as the thickness is not uniform, the generatrix of the back of this lip will be modified by the variation, as shown in Fig. 85. The construction of the diagram is identical with that of Fig. 80, except that as the normals *an*, *ao*, etc., are of different lengths, their extremities do not lie in a circular arc; and the use made of this auxiliary curve in finding the true section will be understood by reference to the explanation given on Fig. 83.

section shall present the appearance shown in Fig. 86; *ab* is the front of the blade, *acd*, the back, the precise curvature being determined by considerations in regard to which there is some latitude of opinion. That however may safely be said of the whole formation and proportioning of the propeller, and it is not necessary for us to discuss any of these various views, our object being to explain, as clearly as may be, how to represent correctly whatever may for any reason have been determined on.

The propeller now under consideration affords more than one instance of the necessity of making such representations correctly. We have already seen that, although the mould for the casting upon which the plate of the blade is to be formed can be "struck up" without making a pattern, yet the laying out of the plate to be bent requires an accurate

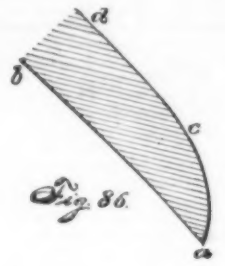


Fig. 86.

knowledge of the form which it is ultimately to assume. And now, the proper formation of the hub with its projections depends upon an equally accurate determination of the surfaces by which it is bounded; as may be seen from the following explanation of the manner in which it is made.

The back surface of the blade, which coincides with the front surface of the lip on the hub, so far as the latter extends, is composed of helical elements. We have seen that a helix may be cut on the surface of a cylinder in the lathe, by giving the tool an endlong motion while the cylinder revolves; and it is clear that the same result can be obtained in the planer, if the cylinder be made to rotate as well as to travel under the fixed tool. Now, let a wooden pattern be made, of the exact form of the required hub, and fixed upon a mandrel, the iron blank for the hub being also keyed upon it in a corresponding position. Let this mandrel be secured on the bed of the planer, in bearings so arranged as to permit partial rotation while the bed travels; and let a bracket, fixed to the tool holder, support a vertical rod of which the lower end shall touch the wooden pattern at a point always corresponding to that in which the tool touches the blank. It is not pretended that this is a precise description of the details of the apparatus, but it conveys an idea of the principle; the axis of the mandrel being parallel to the travel, and the wooden pattern being, by a spring weight, or any other means, kept always incontact with the vertical rod, it will be seen that if the pattern move so that the rod touches it along a helix, the tool will touch the blank along a corresponding helix, which will therefore be cut on the metal as it travels, so that finally the blank will be cut to the form of the pattern. That form then must first be determined, and in such a case it is the draughtsman's duty to furnish, not a mere conventional sketch which may enable one who knows more of what is wanted than the drawing tells, to produce the article required without or in spite of the drawing, but an accurate plan which shall so guide one who may or may not know what is wanted, that he can construct it by means of and according to the information conveyed by the drawing.

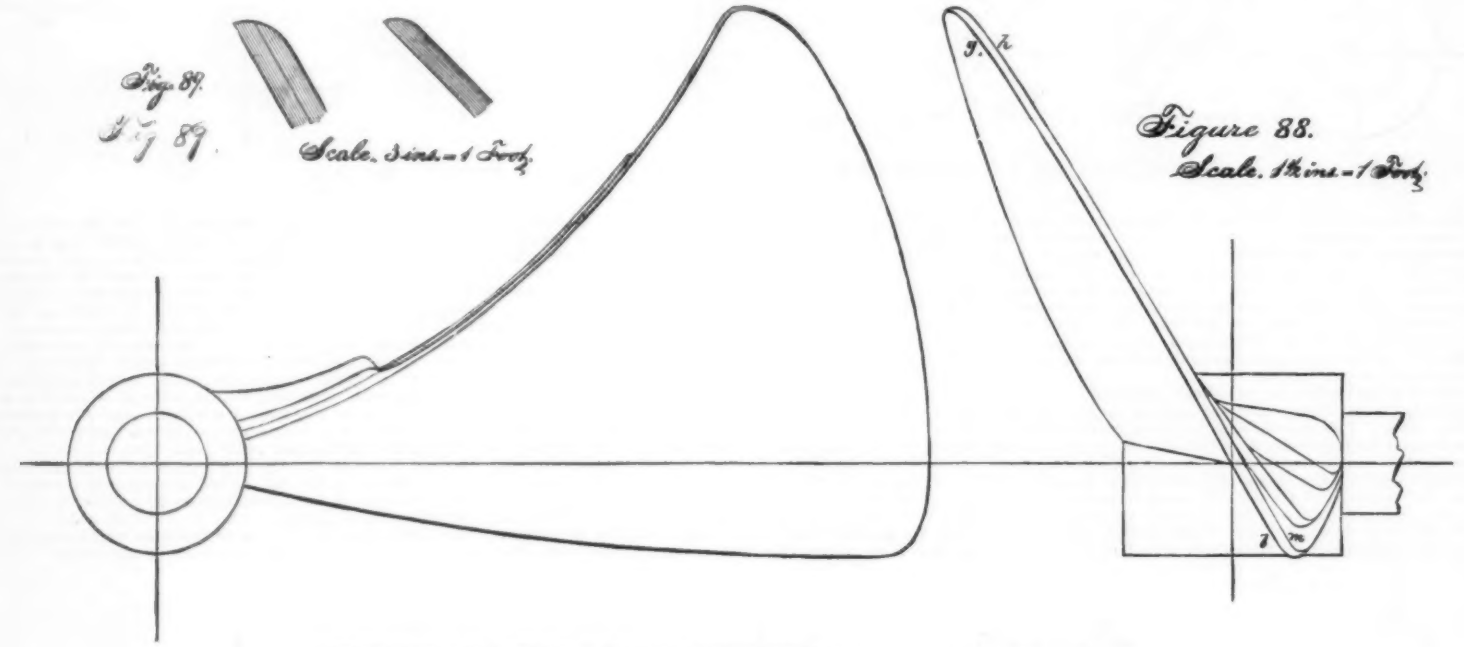
This is one reason, and of itself a sufficient, one for giving a detailed explanation of the process of drawing this hub; another that is, as it is substantially a little propeller, a mastery of this task will enable us to complete the drawing of the blade with comparative ease.

And we begin with this very much as we began with the blade, that is, by drawing the front face; and it is most convenient to place the hub in the same position in relation to the blade that it has all along been supposed to occupy. The generatrix of this face, given in dotted lines in Fig. 85, as *xz*, *x'z'*, enables as to locate and to draw in Fig. 87 as many of the helical elements as may be considered necessary. The lines *fe*, *lm*, in the latter figure, correspond to those similarly lettered in Fig. 81; *f*, as above explained, describes a circle which lies on the surface of the outer cylinder, and therefore cuts the outer helix, at *g*. So also *x*, in revolving, must cut the second helix at *z*; and the inner one, of course, terminates at the end of the hub. Thus we see that the outer line of the projection on the hub may be formed by turning in the lathe, as it will just sweep round within the space bounded by *fe*, *fl*, and *lm*; we have shown the corners of this space as also rounded off, just as in the case of the blade, and the effect of this supposition on the form of the front face is ascertained by repeating the above process, introducing as many intermediate helices between the outer one and the next one shown in the diagram as may be needed.

Now, it becomes necessary to show in some way the varying thickness of this projection, as well as the formation at the ends. No single view can do this; and one of the best means of conveying a clear idea of these points is to make a series of sections, not by planes, but by cylinders; exactly as if the piece were to be put in the lathe, and turned down to a smaller diameter, the operation being repeated as many times as may be required

If we imagine the entire projection to be turned off, or so nearly so that only a thin film is left, the outline of that film on the front face will be the inner helix, *c d*. And knowing the diameter, we can by means of Fig. 85, draw the helix which will bound it on the back, or would do so were it continued to the end of the hub. In order to avoid the sharp angle which would be thus made, however, we round off the ends of strips included between the two helices, as shown in the top view. The curvature of this termination is arbitrary: in this case we have made the outline tangent to *c s*, the end of the hub, and not making an angle with it as in Fig. 86; because it must be recollected that the blade goes in front of this projection, and were the rounding to begin at the front side of the blade, and especially were it such as shown in Fig. 86, the supporting projection would be too much reduced and weakened. So far as the latter extends then, we may suppose both it and the blade to be bounded by edges forming parts of the cones whose outlines are *f e*, *l m*, the corners of the projection being rounded off at the back; beyond that we may begin to take off the back corners of the blade too.

We will now suppose the hub to be turned to another size—say to radius *C a* in the end view. There will be cut from the front and back faces of the projecting lip two other helices, of which the front one is *a b*; and drawing these in the top view, rounding the ends of the included



LESSONS IN MECHANICAL DRAWING. Second Series. No. 13.

Now, were the blade limited by planes perpendicular to the axle, as in Fig. 66, the sections thus formed would be precisely similar to the true sections by the plane, *LM*, just explained, and the drawing could be completed without further difficulty. And were it simply required that the back of the blade, like the front, should just sweep round within the space bounded by the lines *fe*, *lm*, *fl*, with the corners rounded as shown, no new considerations would be involved. For, in Fig. 81, it will be seen that the point *x* in the side view is the highest position reached during the revolution by the point *z* on the acting surface, and the latter might have been found in this way: *x* describes a circle, whose plane is perpendicular to the axis, and is represented by the vertical line, *yz*: this circle lies on the surface of a cylinder, and must cut all the helices which can be drawn upon that cylinder, of which *x' z* is the one belonging to the acting face of the blade, so that *z* might have been located by the intersection of *yz* with this helix in the side view. But we have seen that the back of the blade is made up of helices of the same pitch, one of which lies on this same cylinder; by the aid of the auxiliary curve, Fig. 80 we can locate this, and, drawing it in the side view, the intersection with the same vertical line, *yz*, would fix the point which, in revolving, would reach the position, *x*: whence it would be projected to the circle of that cylinder in the end view, and transferred to the top view in the usual manner. There being no right line elements on the surface of the back, this use of the helical ones must be resorted to; and by repeating the process the edges of the blade might be accurately drawn, were they to be terminated in that manner: and the same may be said in regard to the projections on the hub to which the blade is riveted.

But this is not the case; such a termination might answer very well for the leading edge, since the limiting surface, whether plane or conical, would form an obtuse angle with the back of the blade; but it would form a very acute one in the case of the trailing edge, and this is considered objectionable. For this reason, it is customary to finish the edges in such a way that, if cut by a normal plane at any point, the space as before, we have another cylindrical section; and so on for as many as are deemed necessary for a full definition of the piece required, of which, laying one over the other in their true relative positions, they give a very clear and correct idea by their varying forms and inclinations. A sufficient number of these, with a conventional section like that given in Fig. 82, would suffice for the pattern maker. But it is so easy, now that the difficult work is over, to complete the drawing by giving the visible contour, that it would be absurd not to do so, particularly since it materially aids the comprehension of it as a whole.

Since these sections lie on the surface of cylinders, lines tangent to them, and parallel to the axis, may be considered as also lying on those cylinders, appearing in the end view as points. Thus, *v w* will in the end view be seen as the point *w*, which must be a point in the visible contour of the back, since it represents the extreme left hand point in the curve through *a*, to which *v w* is tangent, and this curve lies on the surface of the back; and in like manner we may determine any number of points.

It is to be observed in regard to the notation of this drawing that, as in Fig. 81, *m* is the highest point of the forward end of the hub, and it happens that the helix *c d* terminates very nearly at the same point; a purely accidental coincidence.

In the top view the helices *c d*, *a b*, *z y*, *g l*, do not intersect each other at the same point; and in regard to the contour of the front face as seen in that view, it will be clear that *g l* hides a part of each of the other helical lines; and that if the whole surface were covered with them, a portion of each would be visible, the last visible point in each being evidently a point in the contour, which must, therefore, be tangent to them all. In the figure we shall have, from the nature of this case, as is evident from the disposition of the helices shown, a sharp curve at *P*, tangent to *c d* and *g l*, as a part of the contour of the front, and another at *R*, as part of that of the back.

By reference to Figs. 82 and 85, it will be seen that, while the front face has a sharp edge at the top, the back has not.

Consequently, there will be no helix at the back, corresponding to $g\,l$ in front; but if we suppose a number of additional sections to be made in the manner above described, near the outer rim, it will appear that the contour as seen in the top view must still be tangent to them all; and were it not for the sections shown, the form of the projection could be indicated only by shading.

In the front view, it results from the manner in which the edges of the back are rounded off, that nothing projects beyond the actual outline of the front face: in reference to which nothing need be added, except that the leading edge is in reality a curve, which, however, so nearly coincides with the right line $l\,m$ until we come to the curve which joins it with the outer helix $l\,g$, that we have not attempted on this scale to draw the double line. It is almost needless to add that all these constructions ought to be made on as large a scale as possible; the working drawing of such a hub as the one here illustrated should be made "full size," and the details of the blade on a scale of three inches to the foot.

Now, in making a complete drawing of the blade, the same method is pursued as in drawing the projection to which it is attached; that is to say, a number of cylindrical sections are made, from which we find points in the visible contour. The appearance of the complete arrangement is shown in Fig. 88; only two views being given, because if the third view be, as we have supposed, such that the acting face be seen, all that is behind that surface will be concealed, and we should have merely a repetition of the side view in Fig. 81. But if we suppose the screw to be a four bladed one, and a complete drawing be desired, then one of the vertical blades will be seen from the front, the other from the back; but if the student can make the constructions already explained, without copying, he can draw that view without assistance; and if he cannot, it would probably do no good to describe the process.

Fig. 88 illustrates a peculiar state of things, which is frequently met with, in which it is almost necessary to represent an object as slightly different from which it is intended to be made. This arises from the fact that, as in the case of the lip on the hub, the outer edge is rounded off on the back, so that while there is a sharp line for the acting face, there is in reality no corresponding line to limit the thickness at the back, and the strictly correct outline in the edge view of the blade would be quite obscure and difficult to understand without shading, which in a working drawing it is well to avoid when possible, in order to save time.

For this reason, it is better to make this drawing, as we have done, as though the leading and trailing edges only were rounded off, but not the rim of the blade, which will, therefore, be represented in the edge view by two helices, $g\,l$, $h\,m$. Fig. 88, the curves joining $g\,l$ with the leading and trailing edges have already been determined; those which join $h\,m$ with those edges in this view may be assumed, as it is to be clearly understood that this whole line is an imaginary one, introduced solely in order to give the effect of relief, by distinguishing the outer rim from the part of the back of the blade seen below it. A similar departure from rigid accuracy, or at least from an iron correspondence between the two views, is made in the case of the edge of the second plate, whose edge is actually to be rounded off, but is in this view shown as though it were not. But since the reading of the drawing is facilitated by this, the discrepancy is perfectly justifiable, in view of the fact that the workman, in finishing the rim, must be guided wholly by the conventional section, Fig. 82, and for this instruction in regard to the leading and trailing edges, two sections, Fig. 89, are added; one taken when the plate is single, the other when it is double.

By this expedient the outline drawing shows the form of the blade nearly as well as though it were shaded; and the instructions given to the workman on putting it in hand, in connection with the other views, will prevent any possible misunderstanding of the requirements of the case. Fig. 88, it is to be noted, is here given merely as a general plan, to give an idea of the whole when put together; in practice, it would, of course, take the place of the two corresponding views in Fig. 81.

[Continued from SUPPLEMENT No. 93.]

THE BRITISH ASSOCIATION.

A NEW STANDARD UNIT OF LIGHT.

PROFESSOR VERNON HARCOURT introduced a new standard light for photometry to the meeting. He first described the difficulties encountered in measuring the light of gas, owing to the variation of the light of the standard sperm candles due to one cause or another. Thus the height of the barometer and thermometer had always to be taken into account in order to correct the results. The Carcel lamp unit he also alluded to, and pointed out that the uncertainty of the composition of the oil, the height of the wick, and other points, were disturbing causes in the intensity and quantity of the light. In order to get a standard light, he had fixed certain requisites: first, that the combustibles should be of a known composition; and, second, that the same amount should be burnt in a given time, also that the atmospheric changes should have a minimum effect. These conditions he effected by distilling petroleum at 50° Cent., and collecting the distillate. One volume of this petroleum in a vaporized state with three of common air gave the necessary combustible, which could be held in a gasometer. A unit of his light consumed half a cubic foot an hour when burnt at an orifice of a quarter of an inch in diameter. The color of the flame seemed very similar to that of the ordinary gas flame, and hence was suitable for the purpose required of measuring the illuminating power of the latter. By using a gas to give a standard light, no correction for temperature or pressure is required, since it and the gas under examination are similarly affected. Perhaps such a standard light might be useful to photographers by which to determine sensitiveness of various photographic compounds. The expectation of the Section was raised to hope that perhaps some definition of what really constituted white light might be given; but they were doomed to disappointment.

THE LOWER LIMIT OF THE THERMAL SPECTRUM.

LORD RAYLEIGH read a paper on "The Lower Limit of the Prismatic Spectrum," in which he alluded to the researches of Sir J. Herschel on the thermal spectrum. (See Hunt's "Researches on Light" for a figure). He gave a resumé of the two methods Sir J. Herschel adopted of tracing the limits of the spectrum. In the first, he coated one side of a paper with lamp-black, and then brushed alcohol over the other and exposed. The portions where the dryings first took place indicated the thermal maxima. These points he had called α, β, γ, and δ, and stated he also found traces of another maximum, ε. Lord Rayleigh had repeated these experiments, but with different results to those above mentioned. He found that he got no results beyond ε. What led him to undertake the investigation was the theoretical probability that the change in the refractive index in a prism for different rays must have a limit, and if such were the case the thermal spectrum should stop abruptly. He explained how this theoretical limit were arrived at. If the prism receiving the sun's rays were set at the angle of minimum deviation from each ray, and the length of the spectrum were taken as the abscissæ, and the ordinates formed of the refractive indices, it would be found that on joining these ordinates a nearly straight line was formed, which would cut at a certain distance from the limit of the visible spectrum, between which points the invisible thermal spectrum must lie. The limit of Sir John Herschel's thermal spectrum lay far beyond this point, and it was to rectify these results that Lord Rayleigh undertook the investigation. By the alcohol method he found his own to agree with theory. In order to further test his results, he repeated Sir John's experiments, which he made by brushing over paper—whilst exposed to the spectrum—ferricyanide of potassium and oxalate of iron. This combination readily changed in the thermal rays to a brownish color, eventually changing to Prussian blue. In these experiments he found the same results obtained. He had brought before this Section these experiments in order to obtain an elucidation of the seeming discrepancies. He said that if the base of the prism used by Sir John were polished, the internal reflections from the surfaces, perhaps, might be the cause of it. (This was the case in the prism that Sir John used). In answer to questions put to him, Lord Rayleigh stated that, although in his experiments he had employed a carbon disulphide prism, yet he had obtained the same results when using flint glass or rock salt prisms.

Mr. Spottiswoode said that in some polarized heat experiments he had found an abrupt termination of the thermal spectrum.

Captain Abney, on being called upon by the President, said he had not much to add in the matter. In photographing the ultra red end of the spectrum, he had found that the state of moisture in the atmosphere had affected light obtainable in a marked degree, and suggested that this, perhaps, might be the cause of the discrepancy.

Lord Rayleigh said that he had placed a cell containing water before the prism, and had found it diminished the length of the thermal spectrum considerably; but he did not think this accounted for it altogether. Four inches of water, he said, represented the moisture in the air when entirely saturated, and the thickness of water he used was a fair representation of the amount that might be expected to intervene between sun and the prism. He hoped other experimenters would repeat his experiments.

THE TELEPHONE.

By W. H. PREECE, M.I.C.E.

IN the year 1837, Page, an American physicist, discovered that the rapid magnetization and demagnetization of iron bars produced what he called "galvanic music." Musical notes depend upon the number of vibrations imparted to the air per second. If these exceed 16, we obtain distinct notes. Hence, if the currents passing through an electromagnet be made and broken more than 16 times per second, we obtain "galvanic music" by the vibrations which the iron bar imparts to the air. The iron bar itself imparts these vibrations by its change of form each time it is magnetized or demagnetized.

De la Rive, of Geneva, in 1843, increased these musical effects by operating on long stretched wires, which passed through open bobbins of insulated wire.

Philip Reis, of Friedrickdorf, in 1861, produced the first telephone which reproduced musical sounds at a distance. He utilized the discovery of Page by causing a vibrating diaphragm to rapidly make and break a galvanic circuit. The principle of his apparatus is as follows: There is a hollow wooden box into which the operator sings through a mouthpiece. The sound of his voice throws a diaphragm into rapid vibration, so as to make and break contact at platinum points at each vibration. This interrupts the current flowing from a battery as often as the diaphragm vibrates, and magnetizes and demagnetizes an electro-magnet as often. Hence, whatever note be sounded into the box, the diaphragm will vibrate to that note, and the electromagnet will similarly respond, and therefore repeat that note. Musical sounds vary in *tone*, in *intensity*, and in *quality*. The *tone* depends on the number of vibrations per second only, the *intensity* on the amplitude or extent of these vibrations: the *quality* on the form of the waves made by the vibrating particles of air.

It is evident that in Reis' telephone, everything at the receiving end remained the same excepting the number of vibrations, and therefore the sounds emitted by it varied only in tone, and were therefore notes, and nothing more. The instrument remained a pretty philosophical toy, and was of no practical value.

Cromwell Varley, in 1870, showed how sounds could be produced by rapidly charging and discharging a conductor.

Elisha Gray, of Chicago, in 1873, succeeded in producing tones from the finger when rubbing a dry sonorous body, such as an ordinary tin can, while the intermittent currents sent by a vibrating tuning fork were passing through it; and by attaching an electro-magnet to a hollow sounding box, open at one end and closed at the other, he was able to reproduce exactly the *tones* of the musical notes transmitted. His electro-magnet had its armature rigidly fixed to one pole, and separated from the other by a space of one sixtieth of an inch. He called it a *resonator*. The vibrations of this armature were imparted to the sounding box, and became thereby magnified. He constructed a key board of two octaves compass, with steel reeds, each of which was tuned to its proper note and maintained in vibration by electromagnets. When the key corresponding to any note was depressed, its corresponding reed was connected to line, and the proper number of currents transmitted to the distant station, where they operated the resonator, and there reproduced the note. In this way tunes were played, and the instrument became an electric organ. By attaching organ pipes to his resonator he magnified the sounds, and was able to fill a large hall with music played at places from 90 to 280 miles away. More than that, he proved the practicability of transmitting chords and composite sounds to distant places.

Gray also invented a method by which the intensity of the note as well as their tones could be transmitted, but it remained for Prof. Graham Bell, of Boston, who has been working at this question with the true spirit of a philosopher since 1872 to make the discovery by which tone, intensity and quality of sounds can all be sent. He has rendered it possible to reproduce the human voice with all its modulations at distant points. I have spoken with a person at various distances up to thirty-two miles, and through about a quarter of a mile have heard Prof. Bell breathe, laugh, sneeze, cough and, in fact, make any sound the human voice can produce. Without explaining the various stages through which his apparatus has passed, it will be sufficient to explain it in its present form. Like Reis, he throws a diaphragm into vibration, but Prof. Bell's diaphragm is a disk of thin iron which vibrates in front of a soft iron core attached to the poles of a permanent bar magnet. This core becomes magnetized by the influence of a bar magnet, inducing all around it a *magnetic field*, and attracting the iron diaphragm towards it. Around this core is wound a small coil of No. 38 silk-covered copper wire. One end of this wire is attached to the line wire, the other is connected to the earth. The apparatus at each end is identically similar, so that it becomes alternately *transmitter* and *receiver*—first, being put to the mouth to receive sounds, and then to the ear to impart them. Now the operation of this apparatus depends upon the simple fact that any motion of the diaphragm alters the condition of the magnetic field surrounding the core, by strengthening or weakening it, and any alteration of the magnetic field—that is, either its strengthening or weakening—means the induction of a current of electricity in the coil. Moreover the strength of this induced current depends upon the amplitude of the vibration, and its form on the rate of vibration. The number of currents sent of course depends upon the number of vibrations of the diaphragm. Now each current induced in the coil at one end of the line passes through the line wire to the coil at the other end of the line, and there it alters the magnetization of the core, increasing or diminishing its attraction for the iron diaphragm. Hence the diaphragm is vibrated also, and every vibration of the one diaphragm must be repeated on the other diaphragm with a strength and form that must vary exactly together. Consequently, whatever sound produces the vibration of one diaphragm is repeated in the other, because its vibrations are an exact repetition of the former.

It is quite evident however that Bell's telephone is limited in its range. The currents operating it are very weak, and it is so sensitive to currents that, when attached to a wire which passes in the neighborhood of other wires, it is subject to be acted upon by every current that passes through any one of these wires. Hence, on a busy line, it emits sounds that are very like the pattering of hail against a window, and which are sometimes so loud as to overpower the effects of the human voice.

Now Mr. T. A. Edison, of New York, has endeavored to remedy these defects in Bell's Telephone by introducing a transmitter which is operated by battery currents whose strengths are made to vary directly with the quantity and intensity of the human voice. In carrying out his investigations in this field he has discovered the curious fact that the resistance of plumbago varies, in some ratio inversely proportional to the pressure brought to bear upon it. Starting from Reis' transmitter he simply substitutes for the platinum point a small cylinder of plumbago, and he finds that the resistance of this cylinder varies sufficiently, with the pressure of the vibration of the diaphragm, to cause the currents transmitted by it to vary in form and strength to reproduce all the varieties of the human voice. His receiver also is novel and peculiar. In 1874 he discovered that the friction between a platinum point and moist chemically prepared paper varied every time a current was passed between the two, so that the rate with which the paper moved was altered at will. Now, by attaching to a resonator a spring whose platinum face rested on the chemically prepared paper whenever the drum was rotated, and currents sent through the paper, the friction between the spring and paper is so modified that vibrations are produced in the resonator, and these vibrations are an exact reproduction of those given out by the transmitter at the other station.

Edison's telephone, though not in practical use in America, is under trial. In some experiments made with it songs and words were distinctly heard through 12,000 ohms, equal to a distance of 1,000 miles of wire.

Bell's telephone is, however, in practical use in Boston, Providence, and New York. There are several private lines that use it in Boston, and several more are under construction. I tried two of them; and though we succeeded in conversing, the result was not so satisfactory as experiment led one to anticipate. The interference of working wires will seriously retard the employment of this apparatus, but there is no doubt that scientific inquiry and patient skill will rapidly eliminate all practical defects.

INFLUENCE OF HEAT UPON MAGNETISATION.

M. J. M. GAUGAIN.

M. Favé had pointed out that when a bar of steel is magnetised at about 350°, allowed to cool, and heated again, the quantity of magnetism augments, and may reach triple the value which it had preserved after cooling. M. Wiedemann maintains that a bar magnetised at an elevated temperature loses on cooling a part of its magnetism: it loses a further portion when heated again, but on cooling it resumes a part of what it had lost. The author believes that this contradiction is due to the circumstance that M. Wiedemann experimented only with bars heated to 100°, whilst M. Favé operated with bars magnetized at a far higher temperature.

ELECTROLYSIS OF SULPHUROUS ACID.

M. A. GUEBOUT.

IT is supposed that on the electrolysis of aqueous sulphurous acid it is resolved into sulphur and oxygen, the sulphur appearing at the negative pole and the oxygen at the positive. The process, however, is by no means so simple. If the aqueous acid is decomposed by a feeble current, the positive pole presents no visible change, but it may be shown by means of chloride of barium that sulphuric acid is produced. At the negative pole there appears a yellow liquid, which is the hydro-sulphurous acid of Schützenberger. If the intensity of the current is varied nothing is observed at the + pole but a production of sulphuric acid. At the — pole the product is modified. With two Bunsen elements, beside the production of the yellow liquid, there is a deposit of sulphur on the electrode, and with three the deposit of sulphur is complete, and a yellow liquor only appears at the outset. A solution of sulphurous acid, therefore, is decomposed like a salt, the acid and the oxygen going to the positive pole, and the hydrogen to the negative pole, where it reduces sulphurous acid to hydro-sulphurous acid, which latter, by its almost instantaneous decomposition, gives rise to a deposit of sulphur.

MICROSCOPY.

List of Plants which afford Raphides, Sphæraphides, Long Crystal Prisms, and Short Prismatic Crystals.

By GEORGE GULLIVER, F. R. S.

As the microscope is now bidding fair to rival—if not supersede—the piano in intelligent families, the present list may form an acceptable guide to a supply of materials for pleasure and profit in an interesting department of microscopic botany, and this too at all seasons; and the objects are in themselves so beautiful, and their preparation and preservation so easy, that slides of them cannot fail to become favorites, as they proved to be when Mr. Hammond exhibited specimens of the different forms of the crystals at a meeting, lately, of the East Kent Natural History Society.

But, quite independently of mere materials for the microscope, plant-crystals deserve far more attention in the cause of science than they have yet received. They are lamentably neglected or confounded, especially as regards the diagnostic characters and taxonomic and physiological significance of the crystals, in our botanical and micrographical books, which will probably have to be corrected by persons who cannot pretend to the rank of botanists. As it might appear invidious to specify the prevailing errors, either of commission or omission, and the names of their authors, I would merely ask the student to consult our current treatises on phytotomy, micrography, and systematic botany, and then compare what is found in those books with what he will easily find far more plainly in the book of Nature.

To enter fairly, however, on this true book, we must first understand clearly the diagnostic characters of the crystals; and these, briefly, are as follows:

1. *Raphides.*—Small, needle like crystals, with long rounded shafts gradually tapering to points at the ends, devoid of angles, and occurring loosely together in bundles of about a score or more, commonly within a cell.

2. *Sphæraphides.*—Globated forms made up of minute crystals or granules, and either smoothish, granular, or still rougher from projecting crystalline tips, and generally within a distinct cell; the cells often forming a tissue, like mosaic work.

3. *Long Crystal Prisms.*—Acicular forms with angular shafts and tips, never occurring loosely in bundles, but either singly or two or more fused together and firmly seated in the plant-tissue.

4. *Short Prismatic Crystals.*—Cubical, long and short squares, polyhedrons, rhombs, and many forms defying definition, though generally more or less prismatic, often not at all so, and occasionally mere crystalline granules; occurring mostly in distinct cells, frequently arranged in chains along the vascular bundles of the leaves and other parts of the plant, or spread in a tissue in the testa.

More ample descriptions are given in my former memoirs. In searching for crystals, a fragment of the plant should be mashed to a pulp by the point of a penknife in a drop of water on the object-plate, then pressed by a thin cover of glass, and examined under an objective of half an inch or deeper focus; and if the part of the plant be first boiled for a few minutes in a solution of caustic potass, the distinctness of the crystals and their cells will be much improved. Thus there can be no difficulty in finding and discriminating the different crystals to which the list is a guide.

It must, however, be borne in mind that several forms may occur either together or in diverse parts in the same plant. To cite a few examples: while raphides are so abundant in the leaves and other parts of tamus, very fine short prismatic crystals are present in testa; in geraniaceæ the sepals contain sphæraphides, and the pericarps the short prismatic crystals; in *thelygonum* and some liliaceæ raphides and long crystal prisms occur together; in vitaceæ, raphides and sphæraphides, and so too in melanthaceæ: in aceraceæ the leaves have sphæraphides and the short prismatic crystals, while the testa has only the last forms, which, too, are remarkable in the testa of ulmaceæ, while sphæraphides are contained in the leaves of this order; in several mesembryaceæ raphides abound, and therewith occur other forms, acicular, flattened, and irregularly angular; in some commelynaceæ and bromeliaceæ three or all four of the forms of crystals appear together in the leaves and stems. It is further noteworthy that, while in the fruit of one compositæ plant, as *serratula tinctoria* or *centaurea nigra*, the long prisms occur, in the same part of some allied plants, as *centaurea scabiosa* and *arctium intermedium*, the short crystals only are found; and this curious specific difference appeared constantly in several specimens from different localities.

In the following list the systematic names are taken from the fourth edition of Professor Babington's "Manual of British Botany," and in most cases the orders only are given; while, except a few common and excellent examples printed in italics, the list is confined to our native plants, and to these only the concluding remarks on the taxonomic value of raphides refer. Even as regards the British flora, this list of plants which afford crystals is neither complete nor always unexceptionable; and though to go abroad might add much to the interest, it would extend the subject inconveniently.

I. RAPHIDES.

Balsaminaceæ.	Liliaceæ (part of).
Onagraceæ.	Typhaceæ.
Rubiaceæ.	Araceæ (part of).
Trilliaceæ.	Lemnaceæ (except Wolffia
Dioscoreaceæ.	*Vitaceæ.*
Orchidaceæ.	*Squill-bulb (Urginea).*
Amaryllidaceæ.	*Hydrangia.*
Asparagaceæ.	*Veratrum.*

II. SPHÆRAPHIDES.

Caryophyllaceæ.	Polygonaceæ (part of).
Geraniaceæ.	*Rhubarb.*
Oxalidaceæ.	*Aralia spinosa.*
Celastraceæ.	Urticaceæ.
Rhamnaceæ.	Tofieldia.
Myriophyllum.	*Passifloraceæ.*
Paronychiaceæ.	Pulp of Pear
Viburnum lantana.	*Cactaceæ.*
Chenopodiaceæ (part of).	*Tetragonia expansa.*
Mercurialis annua.	*Veratrum.*

III. LONG CRYSTAL PRISMS.

Inuleæ.	*Sweet orris.*
Serratula.	*Fourcroya gigantia*
Centaureæ.	*Guaiacum bark.*
Carduineæ	*Quillayaja bark.*
Silybum.	*Bulb-scales of Onion Shallot, Garlick,* and *Leek*
Iridaceæ.	

IV. SHORT PRISMATIC CRYSTALS.

Arctium intermedium.	Tiliaceæ.
Centaurea scabiosa.	Aceraceæ.
Cichorium intybus.	Leguminosæ.
Crepis virens.	Amentiferæ.
Crepis biennis.	Testa of Anagallis.

REMARKS.

I. *Raphides* afford such valuable natural characters that they must be adopted sooner or later in systematic botany. All the species of the first three orders in this list contain an abundance of raphides, and these three are the only orders of British exogens so characterized. This may be a more fundamental and universal diagnostic than any other single one afforded by these plants; fundamental, because it appears from the beginning, sometimes in ovule, and regularly in the seed-leaves and plumule; universal, because thereafter the raphides pervade the plant generally, at all times, in mere fragments of the species, and even after its decay. Thus, for example, a plant of one of these three orders may, at any period of its growth, or even in rotten portions, be surely known from the species of the allied orders. Accordingly, onagraceæ may be truly and sharply defined thus: calycifloral exogens in which raphides abound; and so in like manner of the orders balsaminaceæ and rubinaceæ. Though no exceptions to this rule have yet been found in the British flora, it would be rash to assert that none exist; for even some of the best botanical definitions in universal use are by no means unexceptional. And as to the flora of the world, far more investigations are necessary to determine the taxonomic value of the crystals; but we already know they may in many respects afford useful diagnostics in practical pharmacy and gardening. In floriculture, using this character, I have been able to extricate accidental confusion among young thick-leaved things, truly selecting the mesembryaceæ from the crassulaceæ, and to diminish other plants before they had grown above the ground in the reverse beds of the garden. Thus we have before us another pleasing and instructive employment for the microscope in rural economy. In pharmacology this kind of diagnosis has long been known; and it is ready for useful service, though not enlisted, in the British flora.

II. *Sphæraphides.*—These are more frequent in exogens than raphides, and are common too in endogens. The distribution of sphæraphides has not yet been well determined in the British flora, and in the flora of the world has been still less accomplished.

III. *Long Crystal Prisms* are much less frequent than the three other forms, and in the British plants are by no means common. In the compositæ of the above list these prisms are comparatively small; they occur in the fruit, and may be best seen in the ovary while it is yet soft, and seldom or never elsewhere in the plant. The exotic examples mentioned in the list are all excellent, larger, and easily procurable.

IV. *Short Prismatic Crystals* are widely diffused and abundant. In the compositæ they are, like the long prisms, confined chiefly to the pericarp; and in leguminosæ form beautiful chains along the vascular bundles, which may be conveniently examined in the leaflets of the common white or Dutch clover, and in the young pods of most species of the order.—*Microscopical Journal.*

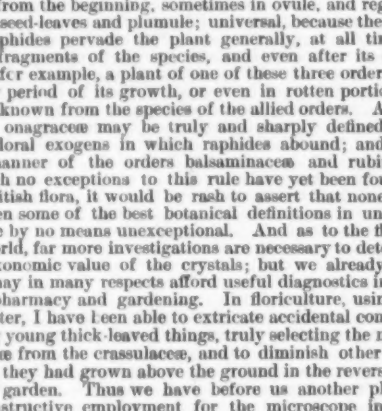
CANTERBURY, 1877.

BINOCULAR MICROSCOPE FOR HIGH POWERS.

By J. TRAILL TAYLOR.

OF the various forms of the binocular microscope none are more deservedly popular than that introduced by Mr. F. Wenham; but, when endeavoring to utilize this method for stereo microphotography, I found it less satisfactory for use with low powers than a plan I shall presently describe, while for high powers it would not answer at all. It is one of the conditions of successful working in this direction that both sets of rays or pencils proceeding from the objective to the eyepieces shall receive precisely similar treatment throughout, but in the Wenham system one half of these rays are allowed to pass onward without interference, while the other half are received by a prism and subjected to two reflections previous to being received by the eyepiece.

FIG. 1.



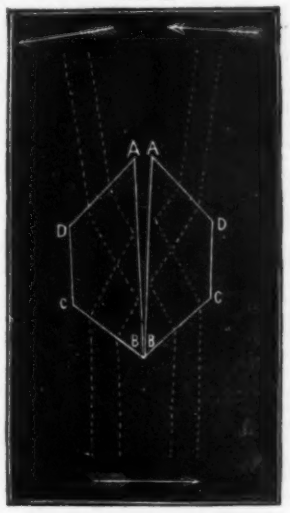
For stereoscopic photography with low powers I believe it will be found by the experimentalist that no method equals in efficiency one which I worked out a considerable time ago, and which was recently published.* It consists in employing an ordinary monocular microscope to the main stage of which is fitted a super-stage capable of being influenced by the mechanical adjustments of the instrument, and also of oscillating from right to left within a limited sphere, for which purpose the slide-holder is pivoted in such a manner that the axis of motion nearly coincides with the object to be photographed. A photograph having been obtained of the object when in one position, that object is tilted in the opposite direction and a second photograph obtained, these two forming a pair which, when combined in the stereoscope, show the object in all its natural solidity.

It will be readily understood that such a plan as that described, while perfect for use with the low powers of the microscope is far from being so when objectives are employed the focus of which is so short that the covering glass of the object almost touches the anterior element of the powers. Under such circumstances recourse must be had to the binocular microscope.

I have already given a reason why the Wenham prism does not answer. But there are other systems of a perfect symmetrical character to which the same objection cannot apply, especially when utilized for purely visual purposes. The chief among those which I have tried are the following:

Nachet's Binocular.—In this arrangement the rays from the object-glass *o* are interrupted in their course by the prism *a* (*fig.* 1), which, presenting one surface at a right angle to the axis of the lens, permits the rays to enter and to pass onward until they reach that surface of the prism which is presented to them diagonally, when they undergo total reflection, passing onwards to the prism *b*, of which there are a pair, as shown in the diagram. The form of these prisms is such as not to permit of any disturbance of the rays except at the surface, where they undergo total reflection and pass up towards the eyepieces. This should be one of the best forms of binocular, because there is reflection without refraction. Yet—possibly owing to errors of workmanship

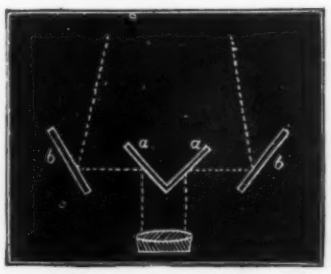
FIG. 2.



in the instrument—in several photographic experiments made by me with a Nachet binocular I failed to secure such definition in the negative as I imagined I had a right to expect. Dr. W. B. Carpenter, while admitting that the Nachet instrument comes near the theoretical standard of perfection, doubts the possibility of its affording a satisfactory view of the more difficult class of test objects; for, although the *general* course of the rays on entering and emerging from each prism may be perpendicular to its surfaces so that they suffer no refraction, many of them will, he says, be slightly oblique, therefore undergoing not only refraction but also some amount of chromatic dispersion. It is perhaps unnecessary to remark that with the Nachet binocular only can the two pictures forming the stereoscopic pair be obtained simultaneously - at least upon one plate of glass.

Stephenson's Binocular.—It is doubtless owing to the consideration just adduced that the greatest amount of success, when using high powers, has not been achieved by means of the admirable binocular system introduced several years since by Mr. J. W. Stephenson. Its form is represented in the following diagram (*fig.* 3), in which the rays proceeding from the object-glass fall upon the surfaces C B of two truncated rectangular prisms, the hypothenuse planes of these prisms being placed together, but inclined to each other at an angle of about 4°. The whole of the light from the object-glass thus enters the prisms under circumstances which compel its retraction towards the surfaces A B, from which it is reflected, and in its now divided form emerges from the surfaces A D, and proceeds onwards towards the eyepieces. In this system there are two refractors and one

FIG. 3.



reflection, and these are still further increased by a second and erecting prism to be found in several of the higher-class instruments of this form. It has been intimated to me that a power of a 1-25th of an inch has been used for visual purposes with a Stephenson binocular microscope; but when I endeavored to use it with a far lower power in connection with photography, good definition was not secured.

I now proceed to describe a method I have adopted, which, being based upon reflection from a metallic surface instead of that from the surface of a prism, is free from those sources of error spoken of by Dr. Carpenter, for here there is no prism employed.

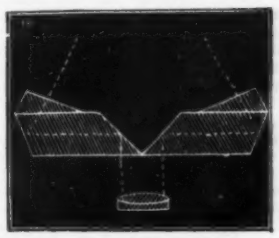
The rays upon emergence from the object glass are received by two small mirrors placed at an angle of 90° to each other, or at 45° to the axis of the objective. These divide the rays and reflect half to the right and the other to the left. So far as concerns photography the conditions by which stereoscopic pictures are obtained are now complete. It is only necessary that the sensitive plates be placed in such a manner, and at such a distance from the mirrors in the line of the emerging rays, as to receive the magnified image formed upon the sensitive surface quite free from

* In *The British Journal of Photography*, *ante* page 392.

those unrecognized refractions which are the inevitable concomitant of the transmission of non-parallel rays through prisms. But I prefer to make each of the pencils undergo a second reflection, and this time, as before, from a *mirror* rather than from a prism, and for the same reason.

In the diagram the system now being described and advocated is clearly shown. *a a* (*fig.* 3) represent the mirrors which are formed of plane surfaces of glass joined together at the proper angle, and then silvered on their faces by the chemical method now so well known, especially in connection with the preparation of mirrors for telescopes. The rays from the object-glass falling upon these are reflected in horizontal directions, but being intercepted by the mirrors *b b*, they are reflected upwards through tubes the existence of which we may imagine. The diagram only indicates the principle, not the detail.

FIG. 4.



The loss of light by the two reflections is much less than would have been imagined, and the photographic image obtained by the use of high powers is better, as regards definition, that I have seen it when obtained by any other binocular system. When employed for visual purposes it is equally efficient, and, from the simplicity of its construction and the accuracy with which the mirrors may be adjusted, it is deserving of attention as an addition to our binocular microscopic resources.

I anticipate an objection that may be offered with respect to the tarnishing of the mirrors by stating that such liability to tarnish is less than is generally imagined, and that the occasional application of a soft wash-leather will keep the mirrors quite bright. Besides, they may be re-silvered at any time at an expenditure of a few minutes' time. But, some time ago, I had the reflections effected by internal impact upon glass, as in the diagram (*fig.* 4). The two reflecting surfaces are similar to those already described; but as the pencil would undergo refraction at the emerging surface I cemented a pair of acute-angle prisms to the reflecting prisms, as shown in the diagram, by which the surface was at a right angle with the emergent rays. This method, although tolerably good for visual purposes, even when high powers are employed (exceptional care being taken in the workmanship), is inferior for photographic use to the more simple reflectors I have described, and which can be employed with a sixteenth of-an-inch power with good effect. In the diagram (*fig.* 4) I have indicated only the *general* principle by which the rays are reflected. To obtain an image quite free from color, great skill must be displayed in the selection of the glass as well as in the forms of the prisms, otherwise fringes of color will inevitably make their appearance. Were it not for this it would be as well to construct the prism out of one piece of glass, when its shape would be very similar to that of the Wenham binocular. When making use of a pair of prisms properly achromatised I have quite failed to discover any color when employing a one twelfth of an inch objective.

If a microscope be constructed according to this principle it will be symmetrical in appearance, and, while being a perfect binocular instrument, may immediately be converted into a monocular microscope by withdrawing, in a "fore and aft" direction, the reflecting system, and deflecting to one side the double body (which must be pivoted at the junction of the axis of the two tubes) until one of them is made to stand in the line of axis of the object-glass.

[THE ACADEMY.]

PHYSIOLOGY.

Distribution of Unorganized Ferments in the Body.—Munk has made the discovery that mixed human saliva contains a proteolytic ferment not unlike the pepsin of the gastric juice. If a small piece of washed blood-fibrin be suspended in fresh saliva acidulated with dilute hydrochloric acid and maintained at a temperature of 40° C., it will be completely dissolved in about four hours, and the solution will be found to contain peptone. This ferment may be extracted from the salivary glands directly by means of glycerine. It must not be confounded with another proteolytic ferment obtained from the same source by Hüfner; for the latter is capable of digesting albumen in alkaline media, the former only in such as are acid. From the gastric and intestinal mucous membranes of the dog and horse, Munk succeeded in extracting a diastatic ferment, differing from that contained in the salivary glands and pancreas, inasmuch as its activity is arrested by the presence of free acid or alkali in very minute proportions (*Central-blatt für die medis. Wiss.*, August 11, 1877). Kühne has also been engaged in a search after ferments. The various organs and tissues subjected to examination were steeped in absolute alcohol, or else extracted, while fresh, with watery solutions of salicylic acid or thymol. From the salivary glands of the pig a pepsinoid proteolytic ferment (clearly identical with that discovered by Munk) was obtained. The gastric mucous membrane of the dog and pig yielded no trace either of ptyalin or trypsin; a substance was obtained from it, however, which breaks up with the formation of leucin and tyrosin in abundance. The intestinal mucous membrane contains a diastatic ferment, with traces both of trypsin and pepsin. The two latter could never be detected in the liver, from which, moreover, only doubtful traces of amylolytic ferment were obtained. On the other hand, an alcoholic precipitate of ox-gall was found (as pointed out by Von Wittich), to be rich in ptyalin; the same process, however, failed to extract it from the biliary secretion of the dog. Many interesting facts were made out concerning the presence of ferments in organs and tissues not directly connected with the digestive function. Generally speaking, traces of pepsin and of a diastatic ferment were pretty extensively met with. Especially noteworthy is the presence of pepsin in the blood and blood-fibrin of the dog. Trypsin appears to be limited to the pancreas and the intestinal contents, none having been discovered in the other solids and liquids of the organism. Whenever we find albumen breaking up with the formation of amido-acide and indol outside the alimentary canal, we may conclude with confidence that the process is due to the operations of bacteria. What becomes of the trypsin poured into the alimentary canal is still uncertain. When introduced under the skin, this substance gives rise to wide-spread injury; but it may be injected into the blood with impunity, and is then eliminated by the kidneys. (Trypsin is the name given by Kühne to the proteolytic ferment of the pancreas which acts on albuminous compounds in the presence of free alkali.)

Action of Chloroform on Septic Microzymes.—Chloroform is usually believed to resemble its congeners in destroying the vital activity of septic organisms. Müntz, indeed, has gone so far as to suggest its employment as a means of distinguishing virulence due to unorganized ferments from that due to the presence of microzymes. Some experiments published by Feltz (*Comptes Rendus*, 6 Août, 1877) seem to show, however, that chloroform differs very widely in its action from alcohol and compressed oxygen. He found that it altogether failed to destroy the virulence of putrid blood when added to it in the liquid state, or when allowed to bubble through it in the form of vapor for a great number of hours.

On Certain Points of Difference between Electric and Tactile Sensations.—In the year 1875, Bloch published the results of an enquiry into the rate at which impressions are propagated along tripetal nerve-fibres (ACADEMY, November 13, 1875). The stimulus employed on that occasion was a mechanical one; a flexible index attached to a revolving wheel being made to touch the skin at known intervals. On repeating his experiments this year in Marey's laboratory, with the substitution of an electric shock (due to momentarily breaking contact with an induction coil) for the mechanical one, he arrived at the unexpected conclusion that the persistence of the impression obeys totally different laws in the two cases (*Société de Biologie*, July 28, 1877). When two electric shocks are given in succession at one point (*e. g.*, the tip of the finger) they become fused and give rise to a single sensation when the interval of time between them is reduced to $\frac{1}{31}$ of a second. If one shock be inflicted on the index, the other on the middle finger of the same hand, they continue to produce distinct sensations till the interval between them falls to $\frac{1}{17}$ of a second. When the index and little finger of the same hand are employed, the sensations do not blend till the shocks succeed each other at intervals of $\frac{1}{11}$ of a second. When the two hands are employed, apparent synchronism does not set in till the shocks are $\frac{1}{13}$ of a second apart. These differences are not observed in the case of mechanical stimuli. Two blows are fused into one sensation when they are separated by about $\frac{1}{18}$ of a second; and this interval is approximately the same whether the twin blows be struck on the same finger, or on different fingers of the same hand, or on different hands. Again, when the electric shocks are given to the two feet instead of the two hands, they cease to be distinguishable at the same point—viz., when they succeed each other at intervals of $\frac{1}{13}$ of a second. In the case of mechanical stimuli, on the other hand, it is found that fusion of twin contacts occurs at longer intervals in proportion as the part touched is less sensitive, and that the interval between the strokes has, accordingly, to be longer in the hands than in the feet, in order that the sensations may be kept distinct.

NEW MEDICAMENTS.

FERROCYANHYDRATE OF QUNIA.—Four parts of quinia sulphate and enough distilled water to form a not too thick mixture are mixed with a concentrated solution of one part of ferrocyanide of potassium, the whole is heated to boiling for a few seconds, and then allowed to cool. The mother liquor, from which more of the salt is obtained on concentration, is poured off the resin-like mass, the latter washed with hot water and crystallized from burning alcohol. It is in small yellowish needles, bitter, slightly soluble in water, freely in alcohol, and efflorescent in the air.

BROMHYDRATES OF QUINIA.—The *basic* salt is obtained by heating 10 grams of quinia sulphate with 80 grams of water to boiling, and adding 3·40 grams dry barium bromide, dissolved in 20 grams of water; the sulphate of barium is filtered off and the filtrate evaporated and crystallized. It forms silky needles, which require 60 parts of cold water for solution.

The *neutral* salt is made in a similar manner, except that the quinia is dissolved by the aid of just sufficient sulphuric acid, and 6·80 grams of barium bromide, dissolved in 25 grams of water, are used for decomposition; the mixture is heated to boiling, filtered, the filtrate evaporated to 35 grams, and crystallized. It crystallizes in handsome prisms, which are soluble in 7 parts of cold water, and freely soluble in alcohol and hot water. Both salts must be free from barium.

TANNATE OF QUINIA.—To a neutral solution of quinia salt add a solution of gallotannic acid, free from resinous matter, until the white precipitate is redissolved; neutralize exactly with solution of bicarbonate of sodium, whereby the quinia tannate will be precipitated; collect upon a filter, drain, dry, powder, and wash with distilled water; then dry again. It is a white amorphous powder, 3·5 parts of which correspond with 1 part of quinia sulphate; if prepared from the latter salt, it always retains a certain quantity of sulphuric acid.

LACTATE OF SODIUM is made by neutralizing lactic acid with sodium bicarbonate, and evaporating; it is very deliquescent.

SULPHOVINATE OF SODIUM.—1,000 grams of sulphuric acid are carefully, and with constant agitation, added to 1,000 grams of strong alcohol, and set aside for several hours; the liquid is then diluted with four liters of distilled water, neutralized with barium carbonate, and filtered from the precipitated barium sulphate. The filtrate is decomposed by a solution of sodium carbonate, and the filtrate concentrated in a water bath and set aside to crystallize; if necessary, the crystals are purified by recrystallization from water, and when dry preserved in well stopped bottles. The yield is about 1,000 grams. The salt forms hexagonal tables, which are very soluble in alcohol and water, have a scarcely bitterish taste, and when heated to 120° C. (248° F.) liberate alcohol. Its aqueous solution is not precipitated by barium chloride or by potassium sulphate.

SYRUP OF HYPOPHOSPHITE OF SODIUM.—Dissolve 5 grams of the salt in 445 grams of simple syrup, and add 50 grams of orange flower syrup. A tablespoonful weighing 20 grams contains 0·20 grams (3 grains) of sodium hypophosphite.—*Amer. Jour. Pharmacy.*

A RUSSIAN traveler, M. Miklucho-Maclay, during his travels in Melanesia observed among the natives of the Admiralty and Hermit Islands a remarkable peculiarity of the teeth of the upper jaw. The incisors project "shovel-like" almost horizontally, and to such an extent as to extend beyond the lips when the mouth is closed. The breadth of the teeth is equal to their visible length.

FUNCTIONS OF THE LIVER.

IN a paper to the Paris Academy of Science, Dr. Claude Bernard contributed some new researches on the sugar-forming theory of the liver, and concluded:—

1st. That the glycogenic property is inherent in the tissue of the liver.

2d. That this property manifests itself during life, and a certain time after death.

STAINING BY NITRATE OF SILVER.

IT used to be a common thing some years ago to see a man whose face was reduced to a blackish shade by the habit he had formerly had of taking nitrate of silver. The *Medical Record* says that Dr. Neumann gave an historical sketch of the observations on the effect of administration of nitrate of silver, and described the results of microscopic examination, which he had lately had the opportunity of making. All the cellular organs, the epidermis, the rete Malpighii, the covering of the sweat-gland, the cells of the inner and outer root-sheaths, were quite free from silver. The metal, however, was abundantly deposited in granules in the upper portion of the cutis, also, in a thin layer, in the walls of the sweat-glands, as well as in the connective tissue portion of the hair-follicles, in the sarcolemma of the striated muscles, between the cells of the unstriped muscular fibres, in the neurilemma of the nerves, and in the tunica adventitia, and between the cells of the middle coat of the blood vessels. The subject was an Italian, aged fifty, who had, during twenty-six years, been in the constant habit of applying nitrate of silver for the removal of enlarged papillæ on his tongue. He had observed, when in hospital, that the nitrate was applied to morbid growths. There was distinct coloration of the conjuctiva bulbi, of the mucous membrane of the mouth and pharynx.

BACTERIA AND VIBRIOS.

IN some recent investigations into the relations of bacteria to the disease of cattle termed *charbon* by the French, M. Pasteur has made some startling observations. He has asserted that bacteria may present themselves under two forms—first, as the rods which alcohol, compressed oxygen, desiccation, and a temperature lower than 100° C. can destroy; and, secondly, as highly refracting corpuscles which, on the other hand, resist a temperature of 120°, and resist also the action of alcohol and of compressed oxygen. These he regards as a mode of generation of the bacteria. They do, of course, also multiply by segmentation, but often on one or several points of the bacterium, globular, highly refracting corpuscles arise, the diameter of which is not greater than the thickness of the bacterium. After these appear, the rest of the rod quickly disappears. If an appropriate liquid is inoculated with these corpuscles bacteria are developed in it just as if the liquid were inoculated with rod-like bacteria, and they constitute the resisting power of the liquids experimented on by some authors.

BACTERIA.

FEW higher authorities could be cited on the question whether spontaneous generation takes place or not than Dr. Roberts, who last month (August) delivered the address on medicine before the British Medical Association at Manchester. His remarks on that occasion, of course, referred to the question of the origin of infectious disease. He said, though the notion of contagious diseases arising from some minute organisms had existed since remote ages, only since the time of Pasteur had this idea assumed the form of a serious pathological doctrine. The discovery during the last decade of organisms in the blood, and their extensive influence upon the treatment of wounds, under the guidance of Professor Lister, had brought to this question universal attention. The author detailed carefully-conducted experiments showing a supported analogy between the action of the yeast plant in fermentation. Also of the *Bacillus subtilis*, and the action of certain contagious fevers. As in small-pox, so in the experiments detailed, there was alike in both cases the same succession of events—viz. a period of incubation followed by a period of disturbance, succeeded by a period of subsidence, and finally restoration to the normal state. There was also great increase of the infective material, and immunity from further attack by the same contagion. Saprophytes, of which the yeast plant and the bacillus are types, are the essential agents in all fermentations, decompositions, and putrefactions, the vast importance of which in the economy of nature and the life of man we are only beginning to realize. All the organisms hitherto found associated with infective inflammations and contagious fevers are of the tribe of bacteria, and in order to a fuller understanding of this association a further knowledge of the origin and attributes of these organisms is necessary. In connection with the origin of these organisms, the aphorism *Omne vivum e vivo* had been assailed. It had been alleged that their origin may be spontaneous by a process of abiogenesis, and that they are not the agents but the products or accompaniments of decomposition. These allegations are, the lecturer said, unsustainable, and he proposed to prove that these bacteria, like other organisms, arise from pre-existing parent germs, and in no other way, and that they are the actual agents in all decomposition and putrefaction. After a minute account of certain other experiments the author claimed to have established: 1st. That organic matter has no inherent power of generating bacteria, and no inherent power of passing into decomposition. 2d. That bacteria are the actual agents of decomposition. 3rd. That the organisms which appear as if spontaneously in decomposing fluids owe their origin exclusively to parent germs derived from the surrounding media. Facts, apparently contradictory to these propositions, were due to its being not understood till lately that, while living monads are killed by a temperature of 140°, the spores of the same variety of monad may survive a temperature of 300°, and that therefore the spores of bacteria may probably survive the feebler heat of boiling water. The practical point to be noted is that a contagium consists in the majority of cases of an independent organism or parasite, and that all infective diseases conform in some fashion to one fundamental type. If septic bacteria are the cause of septicæmia, if the spirilla are the cause of relapsing fever, if the *Bacillus anthracis* is the cause of splenic fever, the inference is almost irresistible that other analogous organisms are the cause of other infective inflammations and of other specific fevers. The occasional production of diphtheria by scarlet fever, the author explained by the capacity for variation or sporting of the contagium in question. And in the same way he suggested an explanation for the otherwise unaccountable

occasional outbreak of cholera in India; the cholera virus in this case being an occasional sport from some Indian saprophyte which, by variation, has acquired a parasitic habit, and having run through countless generations, either dies out or reverts to its original type. In concluding, the author said: "I believe that the doctrine of a contagium vivum is established on a solid foundation, and that the principle it involves, if fairly grasped in capable hands, will prove a powerful instrument of future discoveries."

ERRORS IN DIET.

By Dr. Wilson, British Medical Officer of Health.

It has been estimated by a physician of great eminence that at least 30 per cent. of the patients who consult the doctor owe their ailments to errors in diet, and a tolerably proportion of them come from the upper and well-to-do classes. But, as a rule, they are very troublesome patients to treat, for the mind of the dyspeptic is notoriously fickle and uncertain. He will catch at any nostrum which professes to give relief, and drink any amount of nauseous waters, rather than change his mode of living, although he is assured, and may himself have a very shrewd suspicion, that this is the real cause of all his troubles. If he is put under a regimen which he considers too strict, he will have few scruples in changing his medical adviser, and thus he frequently becomes the ready dupe of the arrant quack, who will buoy him up for a time with false hopes, and afterwards trade upon his fears. Although it is true that disorders of digestion are not all attributable to errors in diet, it is no less true that the great majority of them are, either directly or indirectly, traceable to this cause—indirectly often when they are inherited, and directly, for example, from over-feeding, over-stimulation, a badly regulated dietary, meals eaten hurriedly and at irregular hours, insufficiency of food, and articles of food of very indifferent quality.

But in addition to what are vaguely called disorders of digestion, there is a crowd of other ailments and diseases which may be all placed in the same category, as regards cause and effect. Look, for instance, at the enormous waste of infant life, and the enfeebled constitutions of those that survive, which are due to ignorance or culpable neglect in the feeding of young children. Or, look again at the wide-spread evils of intemperance and over stimulation in steadily and surely undermining the healthy action of almost every organ of the body, and the long train of diseases which follow that smaller habitual excess in eating and drinking so common amongst the upper and middle ranks of society. Livers are constantly going out of order amongst the men, and billious headaches, to say nothing of worse ailments, spoil the temper and the good looks of the women. After a protracted period of immunity, the sedentary man who is fond of a good dinner and a glass of old port, and who boasts of his moderation, is astonished with an attack of gout, and forthwith blames his ancestry. Very possibly his ancestors may have had a good deal to do with it, but he is slow to admit that a little more care on his own part might have prevented all the excruciating pangs to which he has now become a victim. Indeed, it generally requires more than one attack to convince him that, as errors in eating and drinking have been the exciting cause of the mischief, so a careful and more abstemious dietary affords the only chance of a real and permanent cure. Full of good resolves when he is in the clutches of his enemy, he cannot help gratifying some of his old appetites and habits when the attack is over, at first, it may be with no small amount of misgiving, but after a time with less stint and fewer scruples, bearing out the truth of that well-known rhyme—

> "When the devil was sick, the devil a saint would be;
> When the devil got well, the devil a saint was he."

But I need not multiply instances; let me, rather, in passing, venture to make a suggestion. In these days of Conferences and Social Science Congresses, I can conceive of few gatherings which would attract a larger share of interest, and be productive of greater good as regards what we should eat and drink, than a conference of persons who have suffered from gout, and who, by careful living, have prevented subsequent attacks. There might be another section, composed of those who have been victims to dyspepsia, disordered livers, or bilious attacks; but in both sections the discussions could be charactized by frank and open confession of the modes of living before the disorder set in, and what changes were made in the diet, to effect a cure or ward off a relapse. No doubt there would be a good many conflicting views expressed, especially as regards the efficacy of drugs, but I feel confident that there would be a general concurrence of opinion that errors in diet have a much larger share in the production of disease than people are inclined to believe, and carefulness a much wider influence in its prevention and cure.

This, however, by the way. Let me now endeavor to point out very briefly some of the leading facts and principles which should guide us in matters of diet, and in doing so I shall avoid as far as possible entering upon any discussion of the numerous and important chemical and physiological researches which have been made in this direction, though I shall freely avail myself of whatever practical deduction can be usefully drawn from them. In the first place, then, I need hardly say, that whether food be animal or vegetable, it is essential that the diet should contain certain classes of ingredients, namely, those which are required to build up the fabric of the body and repair waste, and those which are necessary for the support of animal heat and the evolution of force, as exemplified in various bodily movements, and in our capacity for work. Now, these ingredients or food, as they have been called, have been divided into the following classes:—the nitrogenous, or flesh-formers; the fatty and saccharine, or body-warmers and force-producers; and the watery and saline, or inorganic substances. The nitrogenous substances nourish the muscles, brain, nerves, and bone; the fatty and saccharine constituents make up the fatty or adipose tissue, which is interspersed throughout all parts of the body, and are directly subservient to all the maintenance of animal heat and the production of animal force; while the watery and saline constituents are essential to the solution and conveyance of the food to different parts of the system, and to the consolidation of the tissues. As examples of the nitrogenous class, we have albumen, which makes up a large part of the lean or fleshy portions of animal food, and which is also contained, though in much smaller quantities, in vegetables; casein, which is found in milk and cheese; and gluten, which is contained in varying quantities in wheaten flour, oatmeal, barley-meal, and the like. As examples of the fatty constituents, we have the fat, which is interspersed more or less freely throughout all animal food, butter, and animal and vegetable oils; while the saccharine constituents are derived from the starch contained in potatoes, the various cereals, tapioca, arrow-root, and other vegetable products.

That a well-arranged diet should contain all these several classes of constituents is alike taught by experience and proved by experiment, and science has also decided with tolerable accuracy, not only what proportion each should bear to the other, but what should be the actual quantities allowed under the various influences of age, sex, and work. The articles of food themselves may be varied almost indefinitely; indeed, variety is a great desideratum in diet, but the proportions and amounts of the several constituents, under certain uniform conditions, cannot be widely departed from without incurring injurious results. As to quantity, an adult may be considered to be taking sufficient for the ordinary requirements of healthy activity if he eats in 24 hours the equivalents of 1 lb. of meat and 2 lbs. of bread. The English soldier on home service receives ¾ lb. of meat and 1 lb. bread daily, and he buys about ¼ lb. additional bread and 1 lb. of other vegetable food. Such a diet is amply sufficient for any adult under ordinary circumstances of light employment; but should extra demands be made upon mind or body, the diet must be increased, or the health will suffer. Active laborers, such as artisans or agricultural laborers, consume about a fifth more nitrogenous food, and twice as much fat, as those engaged in light employment, while the saccharine constitutents are not augmented. Navvies, on the other hand, and those who are employed at hard work, while they require more food, generally err in taking too much animal food and neglecting vegetable food, for it is now well-known that the raising of the muscular powers to the full extent of their usefulness may be effected by vegetable food, quite as well as by increasing the more stimulating and more expensive animal nutriment. With a fair allowance of milk, plenty of oatmeal porridge and oatmeal cakes, potatoes, and other vegetables, a Scotch laborer will do as hard a day's work as any English navvy, and yet take very little butcher-meat from one week's end to the other. Such a diet is as nutritious, more healthy, and much cheaper in country districts, than a diet in which animal food is partaken of twice and often thrice daily, and to a working man cheapness is a great desideratum.

But, then, on the other hand, there are vast numbers amongst the working-classes who do not obtain a sufficiency of nitrogenous food. They subsist almost exclusively on bread, potatoes, and other starchy foods, and they are easily recognizable by their pale looks, attenuated forms, and weak and flabby muscles. More especially is this species of chronic starvation common amongst the wives of the poorer classes, and women employed as seamstresses, and there can be little doubt it is to their insufficient diet that the craving for tea at all hours of the day is in great measure due. Much more nutriment would be obtained, and much mischief avoided, if cocoa were more freely used, for I need hardly say that over-indulgence in tea-drinking induces a long train of dyspeptic symptoms, accompanied by great excitability of the nervous system, which are as painful as they are unfortunately common.

Having thus far endeavored to indicate roughly the importance of a right distribution of the different classes of food-constituents, let me now submit a few hints of a practical kind, in respect to diet as influenced by age. And first, I would direct attention to the feeding of infants. Few people have any adequate conception of the enormous waste of infant life which results from diseases induced by insufficient, improper, and careless feeding of infants. The statistics of the Registrar-General inform us that, out of every 1,000 children born, 150 die before they reach the age of one year, and I do not think it is making too high an estimate if I say that one-third of these deaths are attributable to what may be called starvation-induced ailments. Assuming, further, that the number of children born annually in the United Kingdom amounts to one million—and that is very near the mark—there is thus an annual sacrifice of at least 50,000 infant lives.

Leaving these figures to speak for themselves, I think there are few who would be ready to dispute that the proper food for a new-born infant is the mother's milk; and, in order that this may be sufficiently nutritious, it is necessary that the mother herself should be in fairly good health, and be very careful as regards her diet. Cow's milk, fresh and unskimmed, should, if possible, be partaken of freely every day; and, in respect to solid food, there should be a liberal allowance of animal food, cooked in various ways so as not to cloy the appetite, and plenty of farinaceous food and vegetables. With the exception of a little light wine, beer, or stout—and even these might be advantageously dispensed with in most cases—the less a nursing mother takes of stimulants the better, and she should especially avoid over-indulgence in the use of tea. As regards the infant, after the first few days, it should be suckled from six to nine times daily, and, as far as possible, at regular intervals, after which a gradual reduction may be begun, before weaning, the number of meals should not exceed four. The time for weaning—generally, about the age of nine months—should be determined partly by the growth of the teeth, presuming, of course, that the mother's health is not suffering in the meanwhile. Whenever the first group of teeth appear, which usually happens about the seventh month, the mother may begin to diminish the number of suckling times; and when the second group appear in the upper front gums, the supply may be cut off altogether. If the state of the mother's health prevents her from nursing her child, it may be reared on fresh cow's milk, or goat's milk, or condensed milk. The advantage of using goat's milk when it can be procured, is that, even in towns, the animal may be brought to the house, and the freshness and genuineness of the milk are thus put beyond question. When cow's milk is used, it should at first be mixed with half its bulk of pure, soft, tepid water, and sweetened with a little sugar or sugar of milk, and a grain or two of phosphate of lime should also be supplied with it daily. Condensed milk will not require sweetening, but it should be sufficiently diluted to resemble milk and water. Although it is not liable to undergo the rapid changes to which cow's milk is exposed in warm weather, it is not so suitable as fresh unskimmed milk for constant use, but it may very often be advantageously used during the summer and autumn months. I say nothing regarding wet-nursing, because I am strongly of opinion that, should the mother be unfit to nurse her child herself, a trial ought first to be made, under the supervision of the medical attendant, of artificial feeding, and the numbers of healthy infants who are reared in this way shows that, with proper care, a wet-nurse need only be employed in very exceptional instances. But great care must be exercised, especially as regards the quality of the milk, its quantity, the times of feeding, its proper preparation, and the observance of the most rigorous cleanliness. Indeed, one of the chief objects to the use of the feeding-bottle depends upon the fact that the bottle and flexible tube are not kept sufficiently clean, so that fermentive changes are set up in the milk, and the infant sickens and very often succumbs to diarrhœa. It frequently happens, too, that the water which is used to dilute the milk is not sufficiently pure, and it is a wise precaution always to boil the water if it be derived from a surface well.

Up to six months old, then, the food of the infant should consist of milk, and, if possible, it should not be supplemented by or mixed with farinaceous food, such as arrow-root, sago-flour, and the like. The quantity required, whether it be from the breast or consist of cow's milk, has been ascertained to be a quarter of a pint on the second day, two thirds of a pint on the third day, about a whole pint on the fourth day, and this quantity is gradually increased, until, when the child is six months old, not less than two pints are wanted. Unfortunately, however, when the mother herself is underfed, or when amongst the poorer classes the child is artificially reared, nothing like this quantity is obtained, and the feeding-bottle is charged with all sorts of messes which do not in themselves contain sufficient nutriment, and which the child cannot digest. The consequence is that the child begins to waste away, and whether diarrhœa or other form of disease sets in, the actual cause of death is gradual starvation. The reason why farinaceous foods are unsuited to a young infant is simply this, that an abundant secretion from the salivary glands is essential to the proper digestion of foods of this description, and these glands do not begin to secrete freely until the child is about six months old. After this period the diet may be supplemented, but at first only in a tentative way, by various articles, such as a little broth or beef tea, tapioca, arrowroot, corn-flour, baked flour, and the like. All these and others should have their turn, but, meanwhile, the child should be carefully watched, so that any article which is found to disagree should be discontinued. And here it is necessary to allude to the dangers of weaning the child too early, not the least among which is the liability to suffer from rickets. The child may look thriving enough, but the bones are not sufficiently nourished, and the mischief is not suspected until the limbs become distorted when it begins to move about. It is in order to prevent this mischief that physicians recommend the addition of a little sugar of milk, and a grain or two of phosphate of lime, daily, to be mixed with the milk when the child is artificially fed; so long as it is well nursed at the breast, the mother's milk supplies a sufficiency of the saline as well as the other constituents of food.

After the child is weaned, and up to the eighteenth or twentieth month, when the eye-teeth are cut, milk should still continue to form a considerable portion of the diet, and indeed, during childhood, it may be laid down as a rule that it cannot wholly be dispensed with without detriment to health. Dr. Ferguson, a factory surgeon, who has devoted a large share of attention to this subject, has ascertained from careful measurements of numerous factory children, that, between 13 and 14 years, they grow nearly four times as fast on milk for breakfast and supper as on tea and coffee, a fact which proves incontestably that milk is essential to the healthy nutrition of the young. If tea or coffee is given, they should be given sparingly and largely diluted with milk, and stimulants, except for medicinal purposes, should be prohibited altogether. For breakfast and supper, no more wholesome and nutritious dish can be given than well-cooked oatmeal porridge or gruel, with milk, and bread and butter. Animal food should only be given at the mid-day meal, but at first only on small quantities, and served in soups, broths, or stews, together with mashed potatoes and other vegetables, and followed by a liberal allowance of some farinaceous pudding. Good cooking will make up largely for variety in diet; at the same time, it should be remembered that variety can always be secured without increase of cost, at the most homely nursery tables. Above all, there should be no stinting, because, with very rare exceptions indeed, the natural instinct of a healthy child is a safeguard against gluttony. It is only when the period of puberty is approached, or between that and the period of full growth, that over-eating is likely to be indulged in; and, as any tendencies in this direction can be readily detected, they should be as rigidly checked.

But it may be asked, what about the crowds of very young children who have to be left behind in the impoverished home when the mothers go to work? Many, no doubt, will languish and die, but many might be saved by philanthropic effort, in the establishment of *crèches* or nurseries, where they could be fed and tended during the day at a trifling cost. This, however, is a phase of the subject into which I cannot enter, for, when sufficiency of food cannot be provided, it is mockery to talk of dietetic rules or errors. Let me rather allude to instances, common enough, in which, though sufficiency is guaranteed and expected, it is scandalously denied, and in doing so I need only refer to numbers of private boarding-schools, mostly of a cheap kind, where the dietary may be characterized as a bare subsistence dietary. Although one can appreciate the desire of parents of limited means to obtain a good education for their children at a moderate cost, they should make it a rule, before sending a child to any boarding school, to visit the school and see the pupils, and then they could readily judge by their appearance as to whether they were well fed or not. There is no doubt whatever that numbers of pupils have to suffer in after life from weakened constitutions, not to speak of more immediate ailments, from the scantiness of food supplied at the school to which they have been sent; while on the other hand, there are many pupils who, though well-fed at school, ruin their digestion and become the victims of over-indulgence in after-life, by gorging themselves with sweet-stuffs so long as they have pocket-money to spend. It need hardly be said that excesses in this direction should invariably be discountenanced, and treated as habits which have a low and vitiating tendency, and that undue greediness should be met with censure and reproach.

During the period of youth the diet should be as liberal as for adult age and active employment, inasmuch as bodily growth and the activity of youth have both to be provided for. It is at this stage that lads sent out into the world are apt to suffer from the neglect of a mid-day meal. Owing to the exigencies of business, they take little or nothing during the day, and gorge themselves when the day's work is over, so that, by-and-bye, the digestion becomes spoiled for the breakfast next morning. Indeed, this is a dietetic error which prevails largely in the commercial community. Breakfast and dinner are rightly regarded as the principal meals, the one before and the other after the business of the day is over, but between the two luncheon should never be neglected or partaken of in a hap-hazard sort of way, but the lighter it is the better. If animal food is partaken of at breakfast and dinner, it may be dispensed with at luncheon, and farinaceous foods, vegetables, and fruits should form the staple of the mid-day meal.

But, in all walks of life, one great essential in healthy diet

is regularity of meals. For the active out-door laborer and artisan, an early breakfast before work, a mid-day dinner with an interval of rest, and supper after a day's work is over, has long been proved by experience, to be the most conducive to health. For the business man, a later breakfast, a mid-day luncheon, and a late dinner after the day's work is over, is the best arrangement. For literary men, who write more in the evening than during the day, an early dinner and a light supper will be found to be the most advantageous for steady work. Idlers, to enjoy life, if they possibly can, should dine early if they intend to spend the evening at the theatres and the like; but, if they accept dinner invitations freely, they should be very careful not to eat too much at the mid-day meal. The breakfast hour should be determined, in great measure, by the hour of rising, but, in any case, food should be partaken of before the material business of the day is commenced. Those who liketo take a constitutional before breakfast would find their appetite whetted, and their walk made all the more enjoyable, if they took a little milk, or *café-au-lait*, with bread or biscuit, before starting. Work done before breakfast is always irksome and fatiguing, and, on that account, is very likely to be badly done; and hence, teachers or parents should never exact lessons before the first meal of the day. The last meal, whether dinner or supper, should be sufficiently late for the whole not to be absorbed before retiring to rest. If dinner is the last meal, a cup of tea or coffee with a thin slice of bread and butter during the course of the evening will be found to be very refreshing, but for those who dine early, either what is known as a high tea, or a plain but substantial supper, becomes necessary. To a person in health, three meals a day ought to be quite sufficient, and the stomach ought to be educated to take enough at them to supply his bodily wants. The practice of constantly taking "something" is sure to bring on indigestion, and especially the habit, which of late years has become so fashionable, of indulging freely in the afternoon tea. If too long a period intervenes between dinner and luncheon, the latter should be moved onwards; at any rate it is much safer to be satisfied with some fruit, an ice, or a biscuit than that ladies should continue to "imitate their washerwomen" in lavish afternoon tea-drinking.

And now as to general rules. The three daily meals should be taken at regular hours, and these should be determined mainly by the nature of one's business or occupation. While the appetite should be satistied, the stomach should never be filled so as to induce the feeling of uneasy repletion. The food itself should never be hastily swallowed, and solid food should be carefully masticated. No active bodily or mental exercise should be indulged in immediately after a meal. The diet best suited for the great majority of people in this country is mixed diet, but persons leading an idle life, or pursuing a sedentary occupation, should be careful not to eat too much animal food.

As regards stimulants, the evidence of scientific opinion appears to be largely in favor of total abstinence for persons who are in sound health, and especially for children and young people. At the same time it cannot be doubted that vast numbers of people pass through life in the apparent enjoyment of sound health who are accustomed to take a certain amount of alcohol daily. As to the actual amount which can be partaken of without any apparent detriment, it would appear, from numerous careful experiments, and more especially those conducted by the late lamented Dr Parkes, that 1½ fluid ounces pure alcohol is the limit of moderation. This is equivalent to about 2½ pints of weak table beer, or 1½ pints of stronger ales and porters, or three-quarters of a pint of light French clarets or Burgundies, or 7½ fluid ounces of port or sherry, or 3 fluid ounces of spirits. That this quantity is exceeded by the great majority of so-called moderate drinkers, I think there can be little doubt, but there is as little doubt that this habitual excess, even though slight, becomes sooner or later a fruitful source of recurring pains and discomfort, if not actual disease. In the prime of manhood, the effects may be slight, inappreciable, and transitory; but, by-and-bye, distinct warnings are not wanting that if health is to be enjoyed to the full stimulants should be used but sparingly and with the greatest caution.

WARMING AND VENTILATION.

By CAPT. DOUGLAS GALTON, R.E.

THERE is, perhaps, no subject connected with the economy of the dwelling which has so great a range of importance as that of warming and ventilation. It involves health, comfort, and expense. Ventilation is the science which enables us to regulate the purity of the air within our houses by renewing our supply from the outside; and the problem of ventilation includes a consideration of the degree of purity possessed by the outside air, as well as of methods by which fresh air can be most advantageously admitted into, and vitiated air removed from the house. In its broad sense, therefore, ventilation should determine the site on which the dwelling is placed, as well as its form. It will also be apparent that, since the temperature at which fresh air is admitted influences the mode of admission, as well as the quantity and quality of the air, and its effect upon the individuals submitted to its influence, a consideration of the degree of warmth to be given to the incoming air is necessarily a part of ventilation; the temperature of the air is of especial consequence. While we incessantly require air for the purpose of nourishing us, we also require it for regulating our temperature, or cooling us down.

The quantity of air inhaled and exhaled by an adult in 24 hours amounts, on an average, to about 300 cubic feet, or 2,000 gallons. What we take in and give out during 24 hours, in the shape of solid and liquid food, occupies, on an average, the space of 5½ pints, which is equal to $\frac{1}{1000}$ of the volume of the air passing through our lungs. But this food, and the oxygen of the air which we take in, is necessary for keeping in activity the chemical processes which are bound up with life; and one of the conditions necessary is a definite temperature.

This uniform temperature of the organs is an essential condition of man's life. The blood of the negro in the torrid zone, at its hottest period, is not one-fifth of a degree warmer than that of the Esquimaux, in the coldest time of the year, in the highest latitude. It is always 99½° Fah.

The chemical processes going on in a man produce and give off, on an average, in 24 hours, about 12,000 caloric units A caloric unit is that quantity of heat which will suffice to raise 1 lb. avoirdupois of water, 1° Fah. Thus the heat produced in one day, on an average, by a human being, would suffice to warm 7½ gallons from freezing to boiling point. Of course this varies with the individual as well as with the food and muscular exertion. It follows that the heat of the body is continually being lost. It is lost, 1st, by radiation; 2d, by evaporation; 3d, by conduction.

The loss by radiation and conduction may be exemplified by considering the cold feeling produced on entering an unoccupied house in cold weather, for as radiation is stronger in proportion to the difference of temperature between adjacent bodies, therefore, when the walls of a room are cold, the effect on the occupant is more sensible. As a further illustration, the rapid conduction of iron makes iron railway carriages so unbearable in winter. When the different parts of the human body are exposed unequally to loss of heat, we often say we feel a draught, and injurious effects, such as catching cold, ensue.

The loss of heat experienced by evaporation will be understood from considering the cooling effect on the human body of wind or air in movement, which increases the evaporation on the surface of the body. It follows that when the air is changed in a confined space, if we are to avoid disturbing the temperature of the space ventilated, it is necessary that the temperature of the inflowing air should be regulated.

The quantity of air required in ventilation is governed by the following considerations:

In the process of breathing, the air thrown out from the lungs is deteriorated, the oxygen it contained is diminished, the carbonic acid is increased, a quantity of watery vapor is produced, and a considerable amount of suspended matter is set free, consisting of organic matter thrown off from the body, which assumes a more or less active condition of putrefaction.

Nature has provided in the atmosphere unlimited extent and constant means of putrefaction and of movement. The average movement of air out of doors must be understood, in order to have a correct idea of the real difference between being in a room or in the open air. In our temperate climate the velocity at which air moves amounts, on an average, to about 10 ft. per second; that is to say, to 7 miles per hour. Imagine a frame of the height and width of a human body, which may be assumed to measure about 6 ft. by 1½ ft., or 9 sq. ft. If this is multiplied by the average velocity of the air, it will be found that in one second 90 cubic ft., in one minute 5,400 cubic ft., in one hour 324,000 cubic ft. of air flow over one person in the open air.

In houses these natural conditions are interfered with; the air is enclosed in confined spaces, which allow it to become saturated with impurities, and render it stagnant. Those dwellings are the most healthy in which the natural conditions of the atmosphere are most perfectly preserved.

Chemistry tells us that at least 200 cubic ft. of air per hour is required by a human being for the mere purposes of diluting the carbonic acid and water given off from the body to the same standard as they exist in the atmosphere itself.

But this mode of stating the case takes no cognizance of those aerial poisons eliminated from the skin and lungs, and which in stagnant air are perfectly cognizable to the senses, even after the air has been diluted to the extent mentioned. Indeed, the object to be served by ventilation is primarily the dilution and removal of these poisonous exhalations; and if this be secured, the carbonic acid and water will be removed at the same time.

If it were desired to supply in a room a volume of fresh air comparable with that supplied out of doors, it would be necessary to change the air of the room from three to six times in every minute, but this would be a practical impossibility; and even if it were possible, it would entail conditions very disagreeable to the occupants.

It is thus evident that, in considering the condition of air indoors, we have to seek a standard of admissible impurity in the air, rather than a standard of purity of air, comparable with what we have out of doors.

In judging of the amount of impurity which may be allowed in an inhabited air space the sense of smell, when carefully educated, affords the best indicator of the relative purity and impurity of different kinds of air.

The volume of air which is required to maintain the air of a room at a uniform standard varies with the character of emanations given out by the occupants of the room. For instance, the emanations given out by sick persons, and especially those from bad surgical cases, require for their dilution a greater volume of air than is requisite in the case of healthy persons.

Calculations have been made which show that, theoretically, about 3,000 cubic feet of fresh air per hour per individual should be afforded to preserve the air in a confined space at the required degree of freshness; but, in our climate, a careful practical examination of the condition of rooms in barracks and hospitals, judged of by the test of smell, shows that arrangements which appear to provide for a much less amount than that obtained by theoretical calculation will keep the air of the rooms in a fair condition. These results have pointed to about 1,200 cubic feet of air per hour per individual.

It is very difficult, however, to obtain any accurate measure of the exact quantity of air which enters or passes out of a room. The conditions under which the air flows in and out of a room are so varied. The walls and ceiling themselves allow of a considerable passage of air through them, which is proportioned to the difference between the temperature outside and inside a house, and varies with the materials of which it is constructed. Thus, ordinary bricks are nearly twice as pervious to air as sandstone, and plaster is much more pervious than brick.

If you look at the ceiling you will see that an oil ceiling is blackened where the plaster has nothing over it to check the passage of air, and that where the joists come, and the air has not passed so freely, it is less black. If you break the plaster you will find that its blackness has arisen from its having acted like a filter, and retained the floating particles of dirt while the air passed through.

Ill-fitting doors and windows allow of the passage of a considerable quantity of air.

In a temperate climate, where the changes of temperature of the outer air are rapid and considerable, these means of producing the outflow of air from, and the inflow of air into, a confined space are in constant operation.

A sleeping-room is very warm at bed-time; a rapid fall of temperature outside occurs, and at once a considerable movement of air takes place. The majority of occupiers of sleeping-rooms in England close their windows at night; they often block up the chimney by a register or otherwise to prevent the blacks falling They have no special inlet or outlet for changing the air. In the morning the room would no doubt be very close; but if it were not for the continual insensible change arising from the air passing through the walls, doors, and window chinks, etc., the occupants would be asphyxiated. A well-built house unprovided with special means for the inflow of fresh and outflow of vitiated air is a real source of danger.

For these reasons the form, position, and surroundings of a building are important, because the air thus insensibly coming in, as well as all other air admitted, should be taken from pure sources.

Rooms with a large amount of outside wall space have a better chance of obtaining fresh air than rooms whose walls separate them from other occupied rooms; because the air, filtering in from an occupied room, would necessarily contain more impurities than fresh outside air.

The inflow of air to a room takes place not only from all sides, but also from below.

The air does not cease where the ground begins, but air permeates the ground and occupies every space not filled by solid matter or by water. Thus, if you build on a dry, gravelly soil, where the interstices between the stones are naturally somewhat large, you practically build over a large stratum of air. This air moves in and out of the soil in proportion to barometric pressure, and with reference to the wind.

The fact of this continual free passage of air in and out of the ground makes it important that the ground we live on should be free from impurities. We might just as well (indeed, probably far better) live over a pig-sty than over a site in which refuse has been buried, or in which sewer water has penetrated, or over a soil filled with decaying organic matter; thus, before building on made ground, its nature should be carefully examined.

In proportion, however, as there is a free movement of air in the soil, so is the process of decay, and, consequently, the removal of decaying matter, more rapid. Dead bodies buried in chalk or rubble will decay rapidly, but in clay bodies will be surprisingly well kept, and even after a very long time the features may be identified.

Experiments have demonstrated that there is a considerable quantity of carbonic acid in the ground. The water which comes up from deep springs always contains carbonic acid, with which it is supplied from the ground air. The carbonic acid in ground air is often in sufficient quantity to be highly injurious to life.

These remarks show the immense importance which the soil on which dwellings are placed exercises upon health. In cold or damp weather, when the air in the dwelling is warmer than the air outside, the upward movement of this warmer air will draw in air to supply its place from the ground on which the dwelling stands. This movement would be prevented if the whole surface under the dwelling were covered with an impervious material; but, as already observed, it is difficult to find a building material impervious to air.

Concrete is the most convenient covering to be placed under a building, but it is not impermeable; the lime in it would absorb the carbonic acid from the ground air for a certain time, until it was all converted into carbonate of lime, and then its beneficial action would be diminished. Asphalte is more impermeable than concrete.

The amount of air from the soil may be checked by raising the floor above the surface of the ground, and affording free circulation of air between the raised floor and the ground. In Burmah the dwellings are raised on poles. In Italy and France it is usual to build a basement on open arches, which are used for wood or other stores, over which the building is constructed. It is only comparatively recently that the occupation of cellars as habitations has been prohibited in this country. These considerations show the importance of forming a deep area round a house, which should be carried below the level of the basement floor, under which there should always be ventilation to the outer air.

In connection with the purity of air, it is necessary to consider the temperature and the degree of humidity most favorable for health. The dry bulb thermometer ought to read from 60° Fahr. to 65° Fahr., and ought not, if possible, to fall much below 60° Fahr. The wet bulb ought to read 58° Fahr. to 61° Fahr. In any case, the difference between the two thermometers ought not to be less than 4° Fahr., or more than 8° Fahr., although in the open air, in healthy weather, the difference is sometimes as much as 8° or 9°.

Vapor ought not to exceed 4·7 grains per cubic foot at a temperature of 68°, or 5·0 grains at a temperature of 65° Fahr. The limit of humidity to be allowed is 75° per cent or under.

When the outer air is saturated, as in hot weather, the reduction of the humidity in a room will depend on the increase of temperature of the air admitted.

The capacity of the air for moisture increases enormously with the temperature. Thus, at 50° Fahr. a cubic foot of air is saturated by 1·4 grains; but at 60° Fahr. it requires 5·8 grains. Hence that amount of moisture which would saturate air at 50° Fahr. would give only 71 per cent at 60° Fahr.

If, therefore, the outer air is at a temperature of 50°, and if the temperature inside the room be maintained at a comfortable standard, say 63° to 65°, the incoming moisture would never cause an excess of humidity.

The ventilation of a room is necessarily governed by the size of the room and the number of the occupants.

The size of an occupied and ventilated room effects the purity of the air in the room only by allowing a longer time to elapse before any given standard vitiation of the air is reached, and by making it more easy to supply fresh air without incommoding the occupants. The degree of impurity in the air of an occupied room ultimately in no way depends on the size of a room, but solely on these two things:

1. The rate at which emanations from the occupants are produced.

2. The rate at which the air of the room is being placed by fresh air.

The advantage of large space is—

First, the large room is longer in reaching the state of normal impurity than the small room. For instance, the following table shows the time required to bring air to a definite uniform standard of admissible impurity (viz., 0·2 per 1,000 of CO_2) in different sized rooms:

One man in	10,000	cubic	feet,	3 hours	20 minutes.
"	5,000	"		1 hour	40 "
"	1,000	"			20 "
"	600	"			12 "
"	200	"			4 "
"	50	"			1 "
"	30	"			36 seconds.

Secondly, the inflow and outflow of air necessary to maintain the standard of purity is less perceptible in a large than in a small room; for the chief difficulty of keeping ventilation in action arises from the draughts it causes. Every one objects to a current of air which affects him, and desires that if a window is to be opened it shall be situated behind some one else. There is, moreover, this advantage in the larger rooms, viz., that the larger wall surface and the more

numerous windows will allow of a larger insensible ventilation, and thus larger rooms will have an apparently less degree of impurity than small rooms. Although the uniform diffusion of carbonic acid is very rapid in the air of a room, the organic emanations given out do not in practice diffuse themselves either rapidly or uniformly. They hang about in corners where there are obstructions to the flow of air, or near the ceiling. On this account some space between the occupants of a room is desirable. In sleeping-rooms and in hospital wards, and in fact in all rooms where the height is not less than 10 or 12 feet, the floor space becomes of more importance than cubic space. For adults in sleeping-rooms it is undesirable to have a floor space of less than 50 superficial feet. In hospitals from 90 to 120 superficial feet of floor space is generally afforded; and in fever hospitals, and in surgical wards, much more floor space is frequently desirable.

The ventilation of a room means the removal of a portion of the air in the room, and the supply of a similar quantity of fresh air to take the place of the vitiated air thus removed.

This change of air may be effected in two ways: 1st, by forcing fresh air into the room and allowing this fresh air to displace the air already in the room; or 2d, by drawing the air out of a room and allowing the fresh air to flow in to fill its place. In some cases a combination of both methods is adopted.

The second plan, viz., the extraction of air, is that which is simplest and generally adopted. The extraction may be effected by fans or pumping machinery, but the usual system is to depend upon differences of temperatures for determining the movement of air. A cubic foot of dry air, at the temperature of 32°, and at the sea level, weighs 566 grains. The pressure of the atmosphere on any surface is about 14·6 lbs. to the square inch.

The molecules of air are but feebly attracted to each other, and small increases of temperature or slight diminutions of pressure separate the particles from one another, and thus one cubic foot of expanded air weighs less. Similarly, small decreases of temperature bring the particles nearer together and make the cubic foot of cold air heavier than the standard above mentioned. This expansion and contraction is equal for equal increments or decrements of temperature. When the temperature of air and the space it occupies increases, its density, that is, its weight per cubic foot, decreases.

It follows that, as warmed air expands, it ascends, and as cooled air contracts it falls. It also follows that, as the warmed air ascends, the air around rushes in to fill its place. Everywhere this heating and cooling of the air is going on; the sun's rays, the proximity of a warm body, the vicinity of a cool shaded surface, all cause movements in the currents of air.

In a room, as air is warmed by the bodies of the occupants, it ascends, it comes against the glass of the windows, cools, and falls down. Draughts felt near the windows are not necessarily air coming in from the window, it may simply be the cooled air falling.

It is on this law of the dilatation of air that all the movement of air depends, from the winds and hurricanes to the ventilation of our houses, except where we propel air by fans or other mechanical appliances.

The law which regulates this movement of the air in a confined space, when the temperature is higher than that of the outside air, depends upon the following considerations:

1. Upon the difference of temperature of the air inside the confined space, as compared with that outside.

2. Upon the area of the aperture through which the air passes.

3. Upon the height of the column of ascending air.

Thus velocity of air in a chimney or flue depends on the height of the flue and temperature of the air as it ascends. Therefore a fire lighted at the bottom of a flue produces a current upward in the flue. The extraction of air by flues is the plan usually adopted.

The extraction of air by a properly constructed fan, worked by a steam engine, would be more economical than the flue extraction, especially when the warming of the air, which takes the place of that removed, is taken into account; but the strong recommendation to the chimney is its simplicity and its permanence. It requires comparatively little repair and no skilled labor to look after it. The convenience of this system causes it to be almost universally adopted. The open fireplace is one example of it, the sun-burner another example; but the system is also applied in every room in which there is an opening at the upper part, out of which the warm air can pass, and an opening below, through which fresh air can flow in.

Thus, an ordinary sash window is an example. If the top sash is lowered and the bottom sash raised, the warmed air passes out of the room at the top, and the cooler outer air flows in below.

The air which is supplied to take the place of the air which is removed should be brought in in such a manner and at such a temperature as not to cause unpleasant draught; therefore, in a climate like ours, in winter the air removed must be replaced by warmed air.

There is a marked difference in the comfort of different appliances for warming air. It will be found as a rule that this difference arises from the impurities which they communicate to the air with the heat. Thus, carbonic oxide is formed in a fire when there is not sufficient oxygen supplied to form carbonic acid. Cast iron is pervious to carbonic oxide, it passes through the pores of the iron, and more readily when the iron is hot than when it is cold; carbonic oxide is generated when the supply of air to a fire is insufficient, consequently a cast iron close stove is liable to exercise a pernicious influence on the occupants of a room. Wrought iron is not similarly pervious, and is, therefore, a safer material for close stoves than cast iron.

A room without opening to the air, warmed with hot-water pipes, or by means of a German stove, is often found to be unpleasant; but the unpleasantness arises from the want of change of air. Where there is abundant change of air these effects are not perceived. On this account the open fireplace, which extracts from a room an enormous quantity of air, is always preferred where it can be applied; and it may be stated as an axiom that an apparatus for warming, which does not provide at the same time for an adequate removal of air, is unhealthy.

In order to appreciate the relative effects of different heating apparatus, it is necessary to compare the heat which we obtain from them with the fuel they consume.

The results depend upon the nature of the heat which is applied for warming, as well as open the material through which the heat is conveyed. For instance, radiant heat, *e. g.*, the rays of heat from an open fire, warm the air they pass through very slightly. The rays pass through the air and warm the bodies with which they come in contact, and these give out the heat to the air of the room. Iron and copper, on the other hand, absorb the rays of heat from a fire rapidly, and give them out rapidly; thus more effect would be produced upon the air of a room if an iron screen be placed in front of the fire to intercept its rays than if the rays pass on to the walls, because the iron screen would communicate the heat which it received more rapidly to the air than the walls would.

With hot-water pipes the conductibility for heat of the material of which they are made is of much importance, as is evidenced by the following table of the units of heat transmitted per square foot per hour through a plate one inch thick, the two surfaces differing in temperature one degree:

Copper	515
Iron	2·33
Lead	113
Glass	6·6
Baked clay	4·83

It is thus more economical to use copper or iron as a medium for the transmission of heat to air than to use clay. But, on the other hand, iron parts with its heat rapidly as soon as the heating power ceases to be applied to it; while clay continues to give out heat very slowly for a long time, it thus affords a less variable means of warming the air than iron.

The heat in the warmed air admitted to a building is communicated to the walls and floor and ceiling of the building, until they acquire the temperature of the warmed air. As the walls and roof are in contact with the outer air, there is a continual loss of heat, which has to be made up from the warm air which flows in.

The economy with which buildings can be warmed and kept warm depends, therefore, very much upon the material of which they are composed and on how the materials are arranged. For instance, the walls should be dry; not only is spontaneous change of air through walls impeded if the walls are damp, but damp walls cause a great absorption of heat, from the evaporation of the moisture from their surface. Therefore new houses are unhealthy.

The simple forms of ventilation rest on the principle of an outlet for the warmed air and an inlet for fresh air.

The position of the inlet is of material importance, because the question as to whether draughts are felt or not necessarily depends upon that. The sensation of draught is produced when the current of air impinging on the body is at a lower temperature than the body, because it thus abstracts heat by promoting a more rapid evaporation. Therefore, although a draught is more readily experienced from cold air, it would be felt even with warmed air. For this reason it is desirable to admit fresh air, especially cool air, at the upper part of the room, above the heads of the occupants, and to break up the stream by admitting it at numerous inlets. It thus becomes partially warmed by the air already in the room. The Sherringham ventilator is admirable in this respect, in that it is placed near the ceiling and the incoming air thrown upward.

If, in addition to the Sherringham ventilator, a flue is carried up from near the ceiling of a room, the air of a room, if warmer than the outer air, will pass up the flue, and its place be supplied with air through the Sherringham ventilator—one will act as an outlet and the other as an inlet.

Another simple form of ventilator is Watson's ventilator. The ventilation in this case is obtained by a shaft carried up to the outer air from the ceiling level; the shaft is divided into two parts by means of a vertical diaphraghm, and the shaft on one side is carried rather above that on the other; thus an upward current is produced in the lower limb, and the fresh air flows down the shorter limb.

The velocity of air-flow in the up cast shaft in this case depends upon the difference of length between the long and short limb, which is very small; and, therefore, to produce the same effect as in the case of the first arrangement, a larger area is required. This is a very convenient method of ventilation in large halls and churches, when the doors and windows are closed, and when the warming is effected by hot-water pipes or close stoves, or by some means independent of ventilation.

The action of this ventilator is, of course, completely altered if air is admitted in the lower part of the room, for then an upward current would be determined in both shafts.

Another mode of admitting air is by inlets, on what has been recently called Mr. Tobin's principle. Vertical inlets on this plan, combined with outlets for vitiated air in the upper part of the room, have long been in use; where, however, the extraction shaft is low down in the room, as, for instance, with an open fireplace, the draught from the vertical inlet passes direct to the outlet flue near the level of the occupants of the room; and this causes an inconvenient draught.

In this climate, in private houses, where changes of temperature are so frequent, it is of great advantage to keep the warming and ventilation of the several dwelling rooms independent of each other; on this account the open fireplace has always held its own as being the most convenient, as well as the most cheerful, means of warming and ventilating a room. The open fireplace is a most powerful engine of ventilation for drawing out the air.

With an open fireplace, a velocity will frequently prevail in the chimney of 10 feet, and in some instances of 15 feet per second, thus causing, with a flue 14 inches by 9 inches, the removal of from 30,000 to 45,000 cubic feet per hour. But, as a rule, there is no provision whatever made for replacing the air thus removed. It is allowed to find its way into the room as best it can, by crevices in doors and windows and through the walls. We, therefore, perpetually hear of draughts, of colds, etc. Our open fireplaces nearly warm us by direct radiation of the fire. The hotter we make the fire the more heated air do we send up the chimney, and the more cold air do we bring in to supply its place; thus we are roasted on one side and frozen on the other, and at least five sixths of heat generated by the coal passes up the chimney.

To remedy this, various methods are resorted to. In some cases the hall and staircase are warmed by hot-water pipes or close stoves, with the idea that warmed air will find its way into the rooms.

This arrangement is open to various inconveniences, and, indeed, dangers, unless ample provision is made for the provision of fresh air. For instance, in a house with a central staircase, in the case of the temperature of the house being greater than that of outside air, the staircase becomes a powerful shaft in which the air moves up with considerable velocity. It is often more powerful than the chimney flue because of its larger size, and thus it is often the cause of smoky chimneys.

But it will frequently happen that the open fires in the rooms which will require it to be fed with fresh air, and the warm air shaft of the central staircase, will combine to draw in the air from every available opening. They will draw up the air from the basement, they will draw it, if they can, from the water-closet and sink-pipes, unless the water-closets and sinks are in projecting buildings, cut off by lobbies ventilated from the outer air.

For these reasons, it is of importance, not only to provide fresh air to the staircase, but when open fires are used, to make each room, in which there is an open fireplace, dependent on itself for its supply of fresh air. If the temperature of the room is to be kept up to a pleasant heat, this must be warmed air.

Careful experiments have shown that, with an ordinary open fireplace, five-sixths of the heat passes up the chimney. The obvious method of obtaining warmed air is to utilize some of this wasted heat.

The way in which an ordinary open fireplace acts to create circulation of air in a room with closed doors and windows is as follows: The air is drawn along the floor toward the grate, it is then warmed by the radiating heat of the fire, and part is carried up the chimney with the smoke, while the remainder flows upward near the chimney breast to the ceiling, and, as it cools in its progress toward the opposite wall, descends to the floor, to be again drawn toward the fireplace. It follows from this that, with an open fireplace in a room, the best position in which to deliver the fresh air required to take the place of that which has passed up the chimney is at some convenient point in the chimney breast, between the chimney-piece and the top of the room, for the air thus falls into the upward current, and mixes with the air of the room without perceptible disturbance.

The principle of Galton's ventilating fireplace is derived from these considerations. Fresh air is admitted at the back, where it is warmed by a large heating surface, and then carried by a flue, adjacent to the chimney flue, to the upper part of the room, where it flows into the currents which already exist in the room. The fireplace preserves an equable temperature all over the room, and provides a large amount of fresh warmed air.

The following result of General Morin's experiments on this ventilating fireplace showed that, with the ordinary fireplace, the heat utilized in a room amounted only to 0·125 of the heat given off from fuel, while in Galton's ventilating fireplace the heat utilized in room rose to 0·355 of the heat given off from fuel. Therefore, to produce the same degree of warmth in a room, Galton's fireplace requires only one-third of the quantity of coal required by an ordinary fireplace. It may be laid down as an axiom that every fireplace should be furnished with some means of admitting fresh warmed air.

All inlets for fresh air and all outlets for vitiated air should be adapted to being easily cleaned. Dirt soon accumulates, and if the inlet is foul, the air, however pure, will be fouled in its passage into the room. Moreover, the inlet should be at least two feet above the level of the ground, away from any sources of impurity.

In towns, especially in London, the air is rendered so impure by soot and other matters that any current admitted continuously at one place soon blackens the adjacent walls and ceiling. The only remedy for this is to pass the fresh air to be warmed in the chamber at the back of the fire through a filter of cotton wool to remove the blacks and other impurities.

In cases where the extraction of air by a chimney flue and an open fire is not considered sufficient, and where one or more other flues have to be adopted, it is advisable that these flues should be placed on the same side of the room as the chimney flue, because if placed opposite to it the currents established by the fire would tend to check the current in the flue.

In Germany close stoves are generally used. The amount of fuel consumed in the German stove is comparatively very small. The stove is generally filled with fuel at an opening outside the room, and no removal of air takes place by means of the stove. In German rooms, therefore, the purity of the air is frequently left to depend on the spontaneous change of air which can take place through crevices of windows and doors or through the walls.

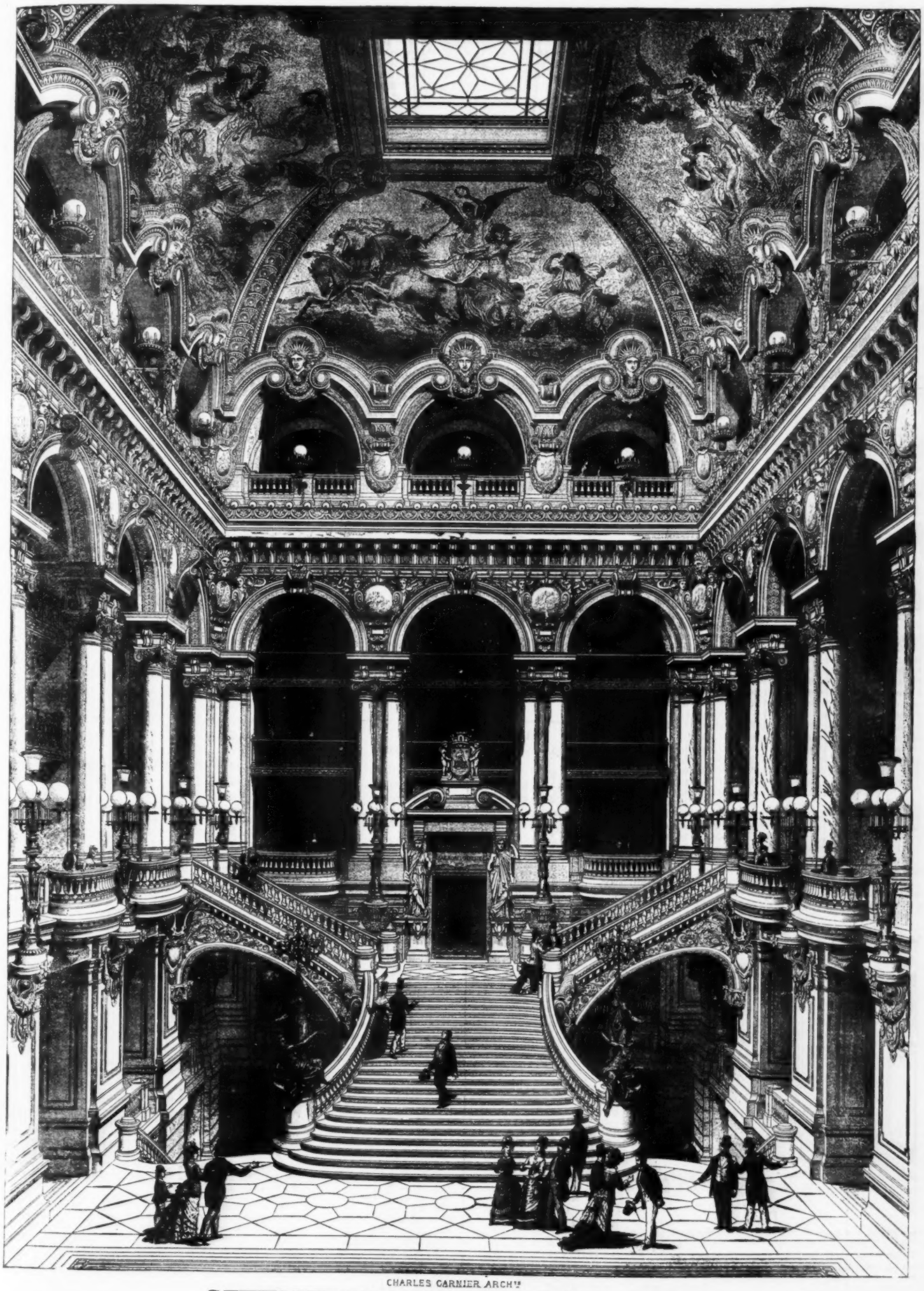
This absence of ventilation is the cause of the saving of fuel in German stoves. This saving of fuel, however, is at the expense of health. Dr. Böhm has adopted for some years the following system (than whom no one has better studied ventilation) in the Rudolf Hospital at Vienna. He there warms fresh air by means of passages constructed in the fire-clay stoves placed within the ward, and the warmed air passes into the ward from the top of the stove. He provides flues of a large size, and proportioned to the size of the ward, from the level of the ward floor to above the roof; and the difference of temperature between the air in the ward and the outer air causes a sufficient current in these flues to ventilate adequately the ward. By this means the fresh warmed air, instead of passing off to the upper part of the ward, and thence away by flues, is made to circulate toward the floor of the ward, thus bringing into action the principle by which the open fireplace is useful in ventilation. But this arrangement destroys one element of economy in the German stove, because the heat generated, instead of being left to pass slowly off into an unventilated room, is removed rapidly by the fresh air passed into the ward, and has, therefore, to be renewed at intervals, instead of, according to the usual custom, the stove being left shut up for twenty-four hours to give off its heat slowly. The larger the supply of warmed air the larger must be the consumption of fuel; and if the heat is to be supplied economically, it must be through a good conducting medium; but the material of the German stove is a bad conductor of heat.

The inventions for warming and ventilation are extremely numerous; but the space allotted to this subject at the Conference on Domestic Economy does not admit of my entering further into the subject. I have only been able in this paper to touch on the fringe of this very large question, and have endeavored to show the sanitary aspect of the subject, as well as to explain the general principles upon which all the detailed inventions for warming and ventilation must be based if they are to be successful.

NEW OPERA HOUSE, PARIS.

Our engraving represents the grand stairway of the new opera house, Paris, which is justly considered as one of the finest examples of modern architecture. Our illustration is from the *American Architect and Building News*. The details of form and ornamentation are full of useful suggestions.

For exterior views of the edifice and for particulars of construction and decoration, on which all the resources of contemporary art have been lavished, reference is made to the back volumes of the Scientific American.



CHARLES GARNIER ARCHT.

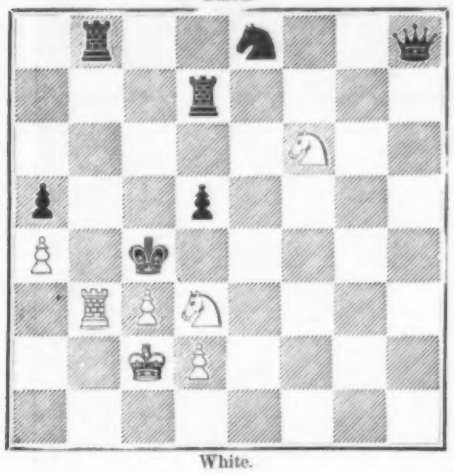
GRAND STAIRCASE OF THE NEW OPERA-HOUSE, PARIS

SCIENTIFIC AMERICAN CHESS RECORD.

[All contributions intended for this department, may be addressed to SAMUEL LOYD, Elizabeth, N. J.]

PROBLEM No. 19. BY H. S. BIRD.

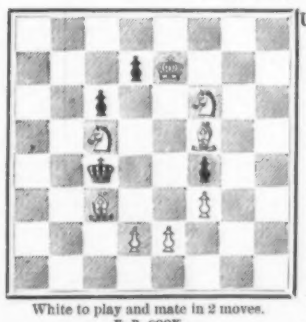
Black.



White.

White to play and mate in four moves.

H. S. BIRD.



White to play and mate in 2 moves.
E. B. COOK.

OUR "distinguished visitor," whose portrait we present this week, has been so long identified with English chess, and has visited so many of our American clubs during the past year, that the most of our readers have had the pleasure of a personal acquaintance, and to all he is known as a powerful and brilliant player.

He received the third prize in our Centennial Tournament, and the special prize for brilliancy of play in the *Clipper* Tournament, but in each tournament, as well as in a set match, he was compelled to succumb to our young champion, Mr. James Mason.

In his match of 1868 with Steinitz, he lost by only two games, the result being Steinitz, 7; Bird, 5; and 7 draws. There is a prospect of an early return match, as Mr. Bird is on the eve of his departure for England, and there has always been a tacit understanding between these players that they should break another lance. In a series of interesting matches in 1873 with Mr. Wisker (the winner of the British challenge cup for two years in succession), the first match resulted in a tie of six to six. The second match, Bird, 7; Wisker, 4. In the third match, Wisker, 7; Bird, 5. The fourth and last match was won by Mr. Bird by a score of five to three. We give specimens of Mr. Bird's play selected from his encounters with these famous players, but cannot close without adding our tribute to his skill as a composer of chess problems of great beauty and merit, one of which we give as a specimen of his talent in this branch; and are particularly pleased to find a player like Mr. Bird, who has encountered the champions from almost every clime, gives it as his candid opinion that he has never known of a good problemist who was not a fine chess player.

Mr. Bird, who enjoys a widespread reputation as a critic and analyst, has just issued a new work wherein he supplies a much needed want by treating of all the latest discoveries in chess openings.

DENIS JULIEN AND THE FIRST ALBION TOURNAY.

THE problem which we give this week by Mr. Julien received the prize in the New York *Albion*, while under the editorial management of Mr. Charles H. Stanley, and is worthy of record as being the first American Problem Tournament. Mr. Julien was of French descent, but he came to this country while quite a lad, and did not learn chess or direct his attention to the composition of problems until the year 1845. He was the proprietor of the St. Denis Hotel of New York, was known as a kind hearted and enthusiastic, as well as a skillful chess player. He was inclined to the old style of problems, and did not admire the more modern innovation of variations, which many of our problemists are running to extremes; but his positions, of which he composed but thirty-eight, will be found to be patterns of beauty and neatness, and he was at one time looked upon as the leading American composer. For some ten years prior to his death, however, which occurred about five years ago, he had entirely given up problem composing, and contented himself with beating many of our leading players across the board. He was born in the year 1806, in a small town called Les Beaumettes, lying in the south of France.

ELIAS STEIN.

ELIAS STEIN was born at Voorbach, near Strasburg, in the year 1748. While comparatively young, he was appointed by William, the last Stadtholder of Holland, teacher of chess to his sons, one of whom became afterwards King of Holland, and the other an Austrian General.

Mauvillon, a chess author, and one of his pupils, says that Stein never found his superior, but departed this life an unconquered chess player. One thing is certain, he succeeded in making chess the favorite game in Holland; and during a recent visit to the Hague, where he died, we found his fame still fresh in the memories of the chess players, although he died in the year 1812.

BIRD AND WISKER.

MR. BIRD.	MR. WISKER.
WHITE.	BLACK.
1. P to K B 4	1. P to Q B 4
2. Kt to K B 3	2. Kt to Q B 3
3. P to K 3	3. P to Q R 3
4. B to K 2	4. P to K Kt 3
5. Castles.	5. P to Q 4
6. P to Q 4	6. P to K 3
7. P to Q B 3	7. Kt to K B 3
8. Q Kt to Q 2	8. P to Q Kt 3
9. Kt to K 5	9. Kt x Kt
10. K B P x Kt	10. Kt to Q 2
11. P to K 4	11. B to K Kt 2
12. P x Q P	12. K P x P
13. Kt to K B 3	13. Castles.
14. B to K 3	14. B to Q Kt 2
15. Q to Q 2	15. Q to K 2
16. Q R to K sq	16. P x P (*a*)
17. P x P	17. Q R to Q B sq
18. B to Q 3	18. P to Q Kt 4
19. P to Q R 3	19. Kt to Q Kt 3
20. B to K Kt 5	20. Q to K 3
21. P to Q Kt 3	21. R to Q B 2
22. Q to K B 4 (*b*)	22. R to Q B 6
23. R to K 3	23. K R to Q B sq
24. B to K B 6	24. P to K R 3
25. Kt to K sq	25. Kt to Q 2
26. Q to K Kt 3	26. Kt to K B sq
27. B x K Kt P (*c*)	27. B x B
28. R x B	28. Kt x B

29. R x Q, and Mr. Wisker resigns.

(*a*) The second player, without committing any serious error up to this point, has already an inferior position. Mr. Bird's play throughout is marked by great vigor and accuracy.

(*b*) White has now an attack which is exceedingly difficult to resist, but black might have made a better defense.

(*c*) Finely played and decisive.—*Westminster Papers*

H. S. BIRD.

BIRD AND STEINITZ.

MR. BIRD.	MR. STEINITZ.
WHITE.	BLACK.
1. P to K 4	1. P to K 4
2. Kt to K B 3	2. Kt to Q B 3
3. B to Q Kt 5	3. K to K B 3
4. P to Q 4	4. P x P
5. P to K 5	5. K to K 5
6. Kt x Q P	6. B to K 2
7. Castles.	7. Kt x Kt
8. Q x Kt	8. Kt to Q B 4
9. P to K B 4	9. P to Q Kt 3
10. P to B 5	10. Kt to Kt 6
11. Q to K 4	11. Kt x R
12. P to B 6 (*a*)	12. B to Q B 4 ch
13. K to R sq	13. R to Kt sq

14. P to K 6, and Steinitz resigns.

(*a*) White plays the ending beautifully. The twelfth move is of the highest order of chess, and wins by force.—*Westminster Papers.*

BIRD AND MASON.

THIS interesting match was played in December, 1875, at the rooms of the New York Chess Club, for the stake of a hundred dollars.

To play at the rate of twenty moves an hour, draws not to count, and the winner of the first eleven games to be declared the victor. Mr. Mason won eleven, Mr. Bird four, and four were drawn. Our space will only allow us to give one of the shorter games.

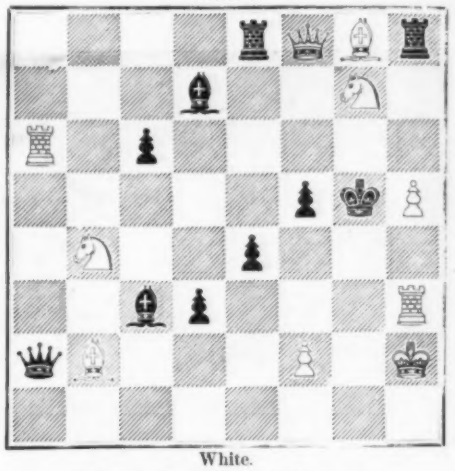
MASON.	BIRD.
WHITE.	BLACK.
1. P to K 4	1. P to K 4
2. P to K B 4	2. P x P
3. B to B 4	3. P to K B 4
4. Q to K 2	4. Kt to K B 3
5. P to K 5	5. Kt to K 5
6. Kt to K B 3	6. B to K 2
7. Castles.	7. P to Q 4
8. P x P *en pas.*	8. Kt x P
9. B to Q Kt 3	9. Kt to Q B 3
10. P to Q 4	10. Kt to K 5
11. Q to Q B 4	11. Kt to Q 3
12. Q to Q 5	12. Kt to Kt 5
13. Q to K 5	13. K to B sq
14. Q x B P	14. P to Q B 4
15. P x P	15. Kt to K 5
16 Kt to Q B 3	16. B x P ch
17. B to K 3	17. Q to Q Kt 3
18. B x B ch	18. Kt x B
19. K to R sq	19. Kt x B
20. R P x B	20. P to K R 5
21. Kt to Q R 4	21. Q to Kt 4
22. Q to Q 6 ch	22. K to B 2

23. Kt to Kt 5 ch, and Mr. Bird resigns.

PROBLEM No. 20. BY DENIS JULIEN.

Prize in the 1st Albion Tournament.

Black.



White.

White to play and mate in five moves.

SOLUTIONS TO PROBLEMS.

No. 15.—BY S. LOYD.

WHITE,	BLACK.
(To mate in two moves).	
1. Q x Kt	1. K x Q
2. K to Kt 5 dis mate.	
(To self-mate in two moves).	
1. Q to Kt 3 ch	1. Q x Q
2. Kt to Kt 6 ch	2. Q or B x Kt mate

BLACK,	WHITE.
(To mate in two moves).	
1. Kt to Q 2 ch	1. K to K 4
2. R x Kt mate	
BLACK,	WHITE.
(To self-mate in two moves).	
1. Kt to Q 2 ch	1. K to K 4
2. Kt to Kt 4 ch	2. B or Q x Kt mate

No. 16.—BY SERGT. WOODS.

WHITE.	BLACK.
1. Q to Kt 8	1. B to B 2
2. Q x Kt	2. Any move.
3. Q to R 2 mate	
	1. Q x Q
2. Kt x P ch	2. Kt or P x Kt
3. Kt mates	

LETTER "I."—BY L. W. MUDGE.

(In this problem the pieces should all be moved one square to the left.)

WHITE.	BLACK.
2. Q to K B 5	1. Any move.
2. Q mates	

END GAME ON STEINITZ'S BOARD.—BY S. L.

WHITE.	BLACK.
1. B to Q 7	1. P to R 7
2. B to B 6 ch	2. K to Kt 8
3. B to R sq	3. K x B

4. K to B 7, and the game is drawn.

James I., King of Great Britain, in the instructions that he left his son how to govern well, amongst other advices concerning play, forbid him chess, because it is rather a study than a recreation. And yet James was a great chess enthusiast himself, and devoted much of his time to the game. It is almost unnecessary to add that Charles did not follow his royal father's counsel, for among his effects, after his death, were found two magnificent chess boards, and we are familiar with the story that is told of this unfortunate monarch, when the news was brought to him at Newcastle of his desertion by the Scots, he was engaged at the time in playing a game of chess, and showed no apparent concern, but quietly continued the game.

Blackwood's Magazine says: "Let no man say that chess is an ignoble subject; it is, if properly considered, as recondite a science as mathematics. Kings, conquerors, and sages have not thought it beneath them to ponder over the chequered board; and it may be that the noble game has contributed, in no slight degree, to the success of their most triumphant efforts."

Benjamin Franklin says: "The game of chess is not merely an idle amusement; several very valuable qualities of the mind, useful in the course of human life, are to be acquired and strengthened by it, so as to become habits on all occasions; for life is a kind of chess, in which we have often points to gain, and competitors or adversaries to contend with, and in which there is a vast variety of good and ill events that are in some degree the effects of prudence or of the want of it."

Walker seems to place some credit on the account which Deschappelles was accustomed to give of the manner in which he learned to play at chess. "I acquired chess," said the great Frenchman, "in four days. I learned the moves, played with Bernard, who had succeeded Philidor as the sovereign of the board; lost the first day, the second, the third day, and beat him even-handed on the fourth; since which time I have never either advanced or receded. Chess to me has been, and is, a single idea, which, once acquired, cannot be displaced from its throne while the intellect remains unimpaired by sickness or age." A wag once said that, in this statement, each day, like the interpretation put by Buckland on the seven days of Moses, must have meant at least a year or more.—*Sat. Press.*